Metal Progress

JANUARY 1958

Metal Progress

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January . . . 1958

The front cover, typifying the international theme, was produced in the studios of Durkin & Rader, Inc., Chicago, by RUDY HAJEK. The background was produced by dropping iron filings on a piece of paper and holding a strong magnet beneath.

Annual International Review of Metallurgy

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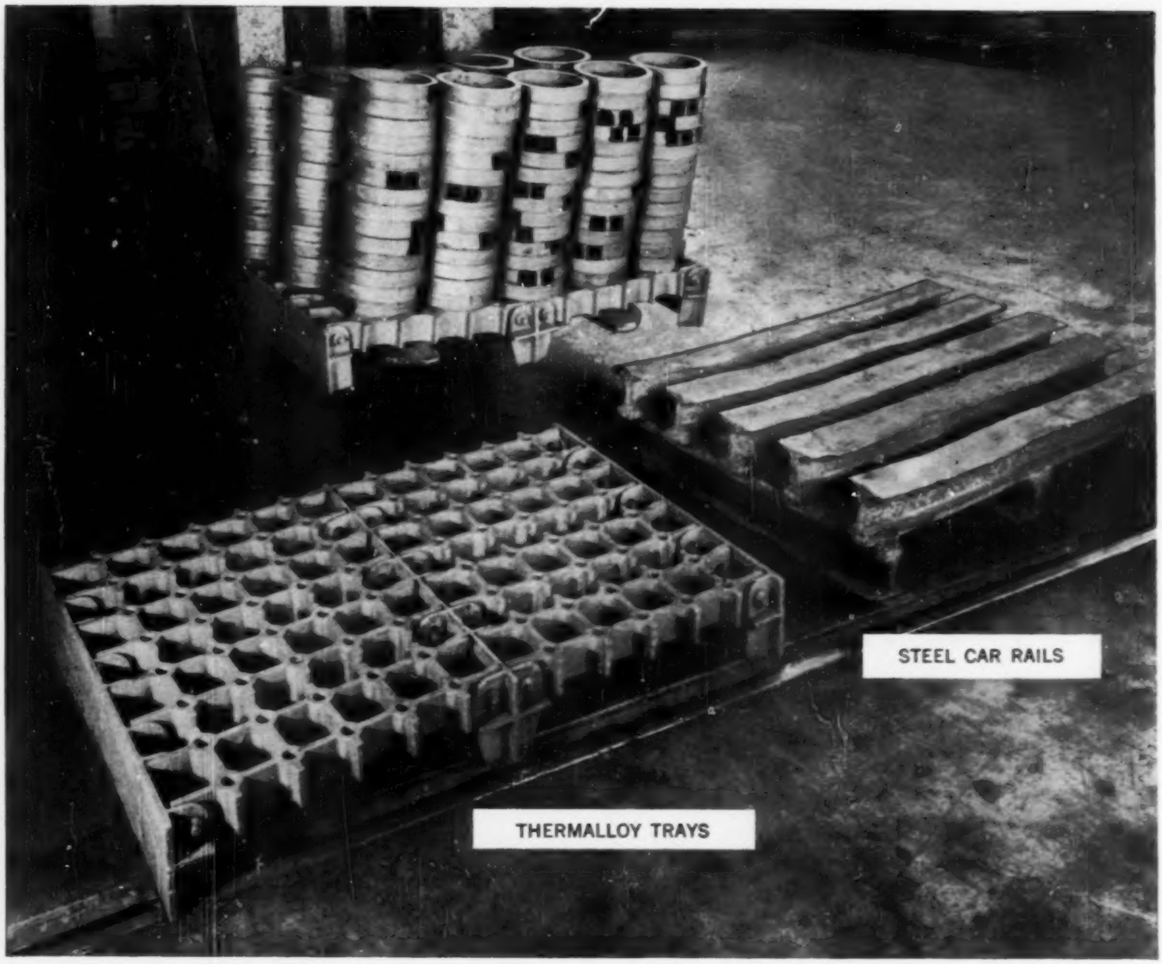


Thermalloy* Heat-Resistant Trays Cut Costs for SKF Industries

At SKF Industries in Philadelphia, steel forgings are annealed in a car-type furnace at temperatures between 1450 and 1650 degrees F. Steel car rails were used to support the forgings in the furnace. But these warped and scaled after short service and became useless.

At the same time, SKF tried the specially designed trays of Thermalloy "30" shown above. These trays have given *six times the service life* obtained from the rails—and are still in use, with many more months of service left. In a cost comparison with the steel rails, SKF found that the Thermalloy trays were less expensive, considering *only* their service life to date.

Thermalloy heat-resistant alloys and Electro-Alloys' design know-how are providing longer service life in scores of heat-treat applications and are saving money for users.

Whatever your heat-treat problem, it pays to contact Electro-Alloys. For further technical information on Thermalloy trays and fixtures, call your nearby Electro-Alloys representative or write for Bulletin T-227. Electro-Alloys Division, 9031 Taylor St., Elyria, Ohio.

*Reg. U. S. Pat. Off

AMERICAN Brake Shoe COMPANY

ELECTRO-ALLOYS DIVISION Elyria, Ohio

Book Review

Atomic Age

Data Sheet

Digests of Important Articles

Departments

As I was saying...

A HAPPY NEW YEAR to Yours and to You and I do mean Yours and You. May all the good things that could happen to anyone be your lot. You are deserving of the best.

1958 should be another splendid year for your A.S.M. because it is headed in the on-and-up direction. It will continue to function in all its past channels and will seek new paths for greater service to the members and the world of wonderful metals. I would love to share with you the enthusiastic letters now reaching headquarters from the Overseas Conferees stating how much the Congress and the A.S.M.'s American Conferees did to make their visit to America a memorable occasion. The highlights of these letters will appear on this page at a later date – but for now I'll acknowledge the letters in your behalf and tell our friends again the pleasure all ASMers enjoyed in having them as our guests.

While the highlight of 1957 was the 2nd W.M.C., the highlight of 1958 will probably be the ground-breaking ceremony for the first building of the A.S.M. of Tomorrow. That historical event will be in early April, and President Mac Young will have a chance to show his ability as an engineer by driving a Big Cat. While a shovel may be used to square the corners of a round building, the Cat will serve well in this instance to indicate the size of the undertaking that has been inaugurated in behalf of the world's basic industry. And these last few words bring to mind a statement made by the chairman of one of the world's largest steel corporations: "The extensive dissemination of important information by the A.S.M. makes that society one of the metals industry's most important assets."

That statement is a remarkable tribute to the A.S.M. and it is with a feeling of pride that all ASMers will realize that while serving the members we also serve industry. Just one example: The A.S.M. collects, edits, produces and distributes annually over one hundred million pages of engineering information on the subject of metals.

"Now, Bill, come down off your high horse; you're feeling your (wild) oats," I can hear you say, and perhaps I am unduly elated over the extremely complimentary statements made about the A.S.M. and its world-wide recognition. But my pride and happiness are not for me – they are for you, the members of the A.S.M., for it is your contributions and cooperation that have made all the past accomplishments possible. And it will be your efforts and contributions that will rocket the A.S.M. into an educational orbit so that its future will be a shining example for all to see.

To you, Mr. ASMer, should go the praise and glory.

Cordially yours,

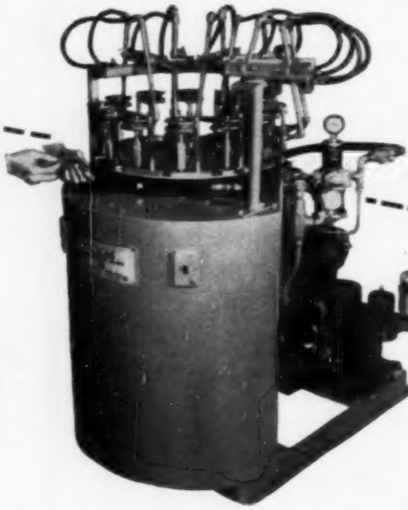
Bill

W. H. EISENMAN, *Secretary*
AMERICAN SOCIETY FOR METALS

our research is your reward

400 CRAFTSMAN SOCKET WRENCHES
Selas-brazed and hardened per hour

Fast, sure, low cost Selas brazing permits joining simplified *socket forging and turned shank* in lieu of a more complex *one-piece forging*. Preplaced, preformed filler ring produces optimum fillet, full strength in every joint.



Space-saving automatic Selas machine does the brazing: simplicity of operation permits use of unskilled labor. Additional savings result from use of accurately patterned brazing heat to harden the AISI 4041 steel wrench socket. Fuel cost only 2½c per hr.

This high quality CRAFTSMAN nut driver is sold by Sears for approximately 79c (set of 7 is about $4.98, varying by region). Selas automatic brazing maintains quality while achieving the required production economy.

High brazing skills are built into this automatic Selas machine through controlled combustion and accurate flame geometry. Specially-designed fixtures adapt to three shank diameters and nine socket sizes. The result is high volume, dependable brazing at lowest cost.

Whatever your brazing needs, Selas will design, engineer and build fully-automatic or semi-automatic equipment for you . . . after simulating your production conditions, using your workpieces, in our laboratory. You get speed, versatility, reproducible uniformity. High labor skills are not required because Selas builds the skills into your machine. And, since Selas designs, constructs, starts-up and services each machine, problems usually associated with divided responsibility are eliminated.

Send for Bulletin No. 31 "Production Brazing and Soldering" and reprints "Gas-Fired Machine Brazing" and "Mechanical Heating Puts Brazing on the Production Line."

SELAS *Heat and Fluid Processing Engineers*
CORPORATION OF AMERICA
DRESHER, PENNSYLVANIA
DEVELOPMENT • DESIGN • CONSTRUCTION

NEW!...

At W-K-M Division of A-C-F Industries, Inc., Houston, Texas, Gulfcut Heavy Duty Soluble Oil has been used extensively on turret lathes for threading, boring, facing, turning, and grooving operations. This Gulf customer says: "Gulfcut Heavy Duty Soluble Oil gives us long tool life and excellent finishes."

Erich Brenner, Foreman at W-K-M, informs Jeff Bolling, Gulf Sales Engineer, about the excellent results obtained with Gulfcut Heavy Duty Soluble Oil.

converter powered furnaces mean flexible melting

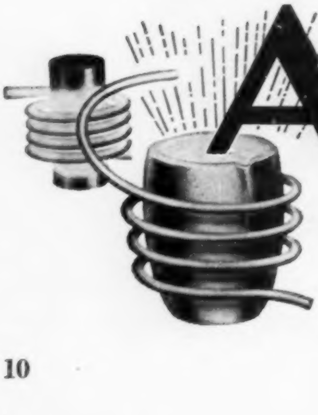
For Precision Casting

Converter powered Ajax-Northrup furnaces have been the birthplace for just about every important alloy discovered in the last quarter-century. But the same economy and flexibility that make them a laboratory necessity make them just as important to industry. In fact, many of today's best known precision casting companies were started with a single Ajax-Northrup high frequency furnace powered by a spark gap converter.

One of the most successful, Precision Metalsmiths, Inc., Cleveland, Ohio, still finds converter powered furnaces ideal for all melting. Because heating must be fast, and the resultant alloys must be pure, high frequency induction heat is the only answer. And the large variety of alloys to be melted—some 92 different ferrous and non-ferrous alloys—makes converter operation highly desirable. The company's four furnaces *could* be powered by a single motor-generator set. But powering each furnace with an individual spark gap converter achieves maximum efficiency and versatility at minimum cost.

Precision Metalsmiths' need for flexibility is not altogether typical. But it does serve to underscore the undeniable advantages of converter powered Ajax-Northrup furnaces for precision castings. Additional details on how converter powered high frequency induction furnaces could improve *your* operation, are available from Ajax Electrothermic Corp., Trenton 5, New Jersey. Request Bulletins 14-B and 27-B.

Associated Companies: Ajax Electric Company — Ajax Engineering Corporation



AJAX NORTHRUP SINCE 1916

AJAX

INDUCTION HEATING-MELTING


SERIES 58
SERIES 56
SERIES 59
available through
HARSHAW SCIENTIFIC
a completely new series of
Stereoscopic Microscopes
CYCLOPTIC
offers these outstanding features
• True three dimensional image
• Long working distance
• Reversible, inclined body
• Large field of view
• Durable EPOXY finish
• Top quality optics
• Broad selection of models
• LOW PRICE
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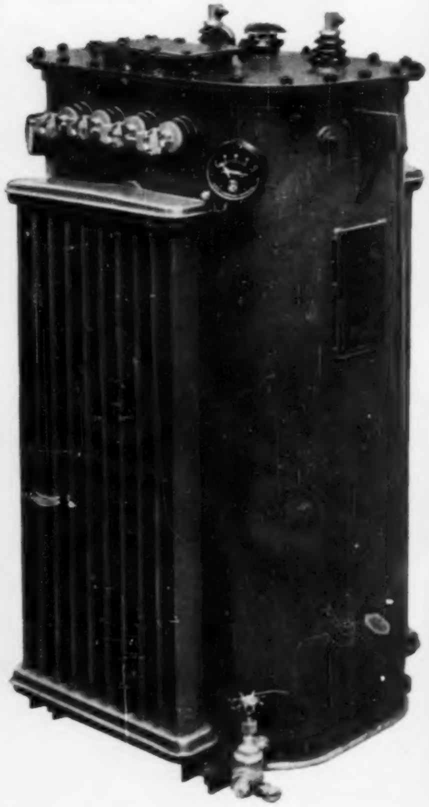
Baton Rouge, La. • Hastings-On-Hudson, N.Y.

Operator places oval carbon-steel tubes in slots and presses them into headers.

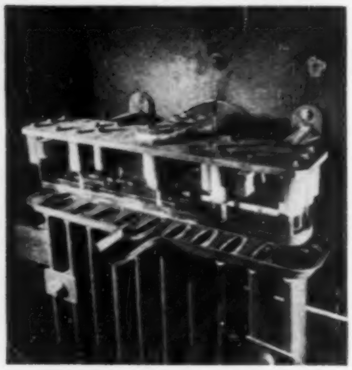
HANDY FLUX is applied with syringe.

Completed radiator attached to transformer.



Pre-formed ring of EASY-FLO 35 is placed in joint area.

Holders position assembly in induction rig, induction coil is lowered, heat applied for 90 seconds; afterward joints are sandblasted to remove flux which could contaminate transformer oil.



How EASY-FLO Brazing Helps Shaw-Perkins Simplify Techniques, Cut Production Costs

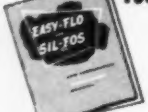
Changing to silver brazing with EASY-FLO 35 brought many benefits to Shaw-Perkins Manufacturing Company, manufacturer of radiators for liquid-cooled transformers. The radiators are made up of banks of steel tubes assembled to inlet and outlet headers. Hot oil from the transformer enters at the top of the radiator and flows downward, returning to the transformer at a lower temperature.

Before Handy & Harman silver alloy brazing entered the production picture, the tubes were arc-welded and gas-welded to the headers. Now, rings of EASY-FLO 35 are preplaced and induction-brazed with results that *any* manufacturer would be happy to talk about: rework is almost nil (arc-welded joints had often failed to pass inspection), production space has been reduced (two silver brazers now do the work of six arc welders in a simplified assembly pattern), lower silver-brazing temperature minimizes possibility of unit failure in service due to metal fatigue. Radiators *look* better, have smoother fillets.

Similar benefits might well accrue to *your* product or production methods through the use of Handy & Harman silver alloy brazing. Get in touch with Handy & Harman on any phase of silver brazing. We will work with you in every way to determine the advantages silver brazing can achieve for you.

FIRST, BULLETIN 20

This informative booklet will get you off to a good start on the values, techniques and economies of low-temperature silver brazing. A copy awaits your request.



Your NO. 1 Source of Supply and Authority on Brazing Alloys

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General Offices: 82 Fulton St., New York 38, N. Y.

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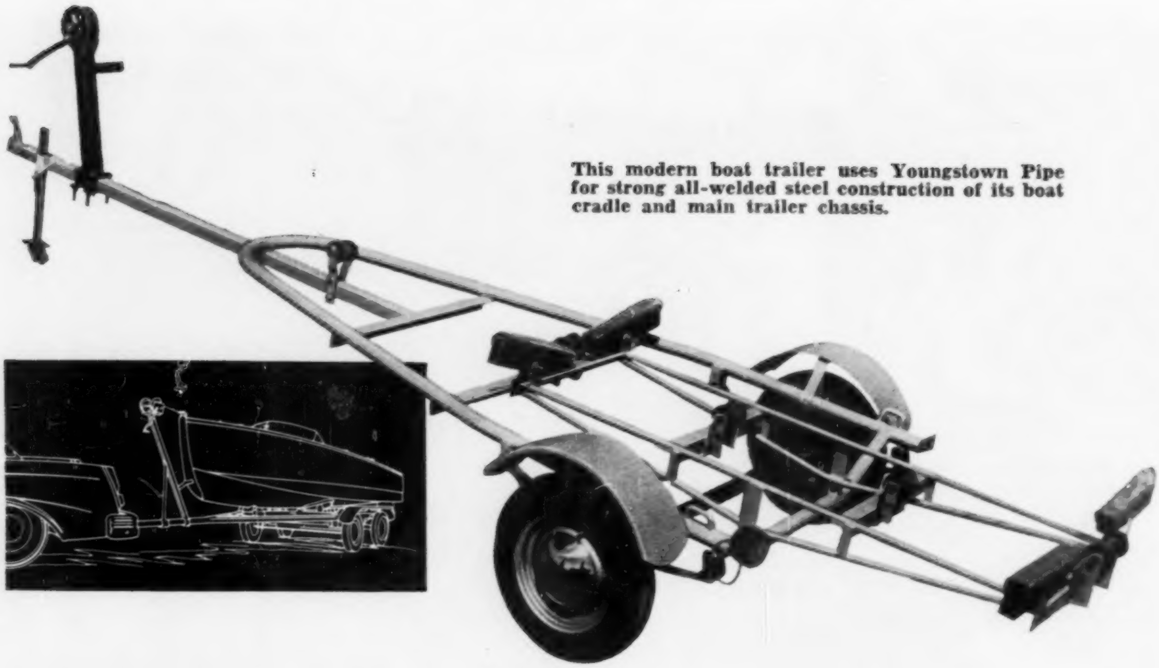
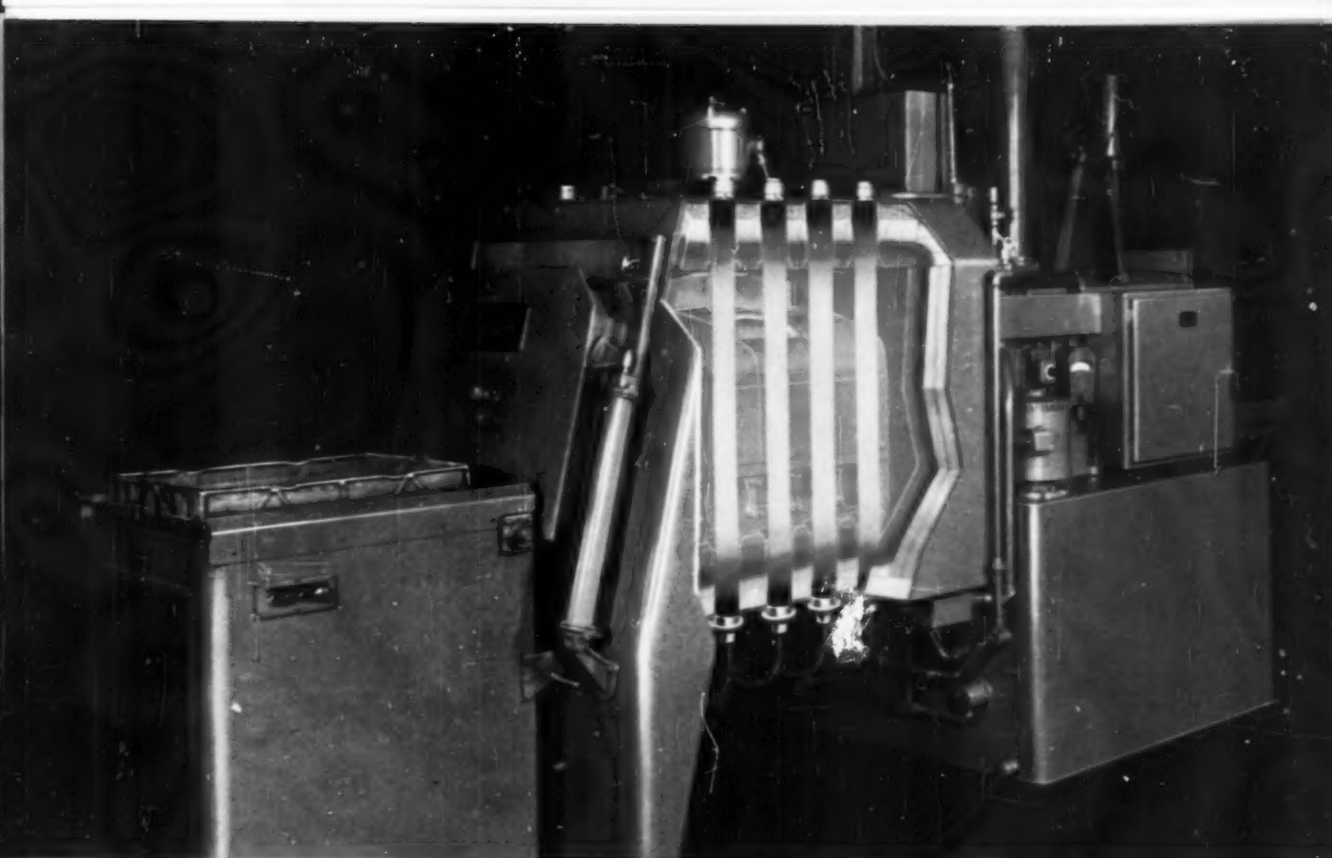




look into this

If it were possible to cut away a portion of an operating furnace, the Ipsen T-4-600 Automatic Heat Treating Unit would appear as shown above. In this unit, 100% forced convection heating is effected by continuously recirculating large quantities of atmosphere—at 40 ft. per second—over the Ipsen heating tubes.

These heating tubes are manufactured of an alloyed ceramic material that easily withstands continuous furnace usage to 2000° F.—tube temperatures to 2700° F.

Ipsen tubes were initially designed for gas-fired heat—however specially designed electric heating elements may be easily inserted into the tubes to permit electric heating, without contamination from carburizing or carbo-nitriding gas.

With a silicone "O" ring at the bottom end, and a flexible bellows at the top, each tube is perfectly sealed under continuous compression, regardless of expansion or contraction.

A recently developed burner gives unusually quiet operation—and 100% complete combustion within the tube.

Based on normal operating conditions, the latest development in the ceramic tube material permits a manufacturer's guarantee of one year.

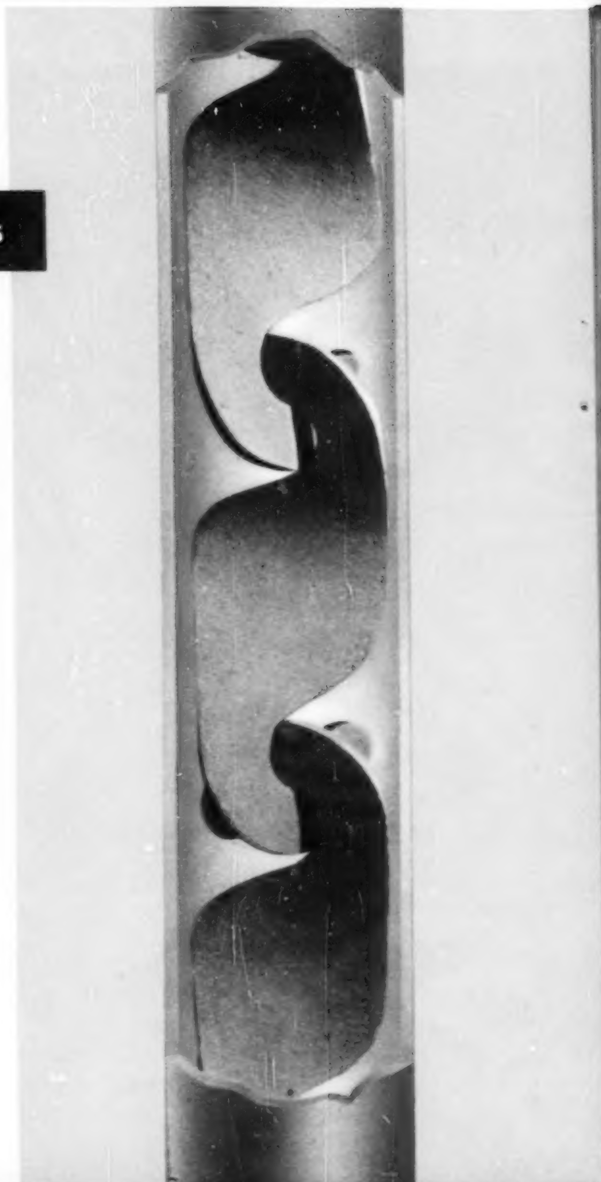
turn to next page for information on the new Ipsen Flame-Busters

AUTOMATIC
Ipsen
HEAT TREATING UNITS

presenting

Ipsen Flame-Busters

...for use with Ipsen alloyed ceramic heating tubes



The new Ipsen Flame-Busters are alloyed ceramic links, suspended chain-like inside each gas-fired heating tube to interrupt the flame path. They're made of a newly developed alloyed ceramic material which withstands direct flame impingement at temperatures up to 3000°F.

Here's what happens: Gases in excess of 2500°F. from the burner at the bottom of the tube pass upward until checked by a suspended series of ceramic Flame-Busters that effectively swirl the high velocity gases.

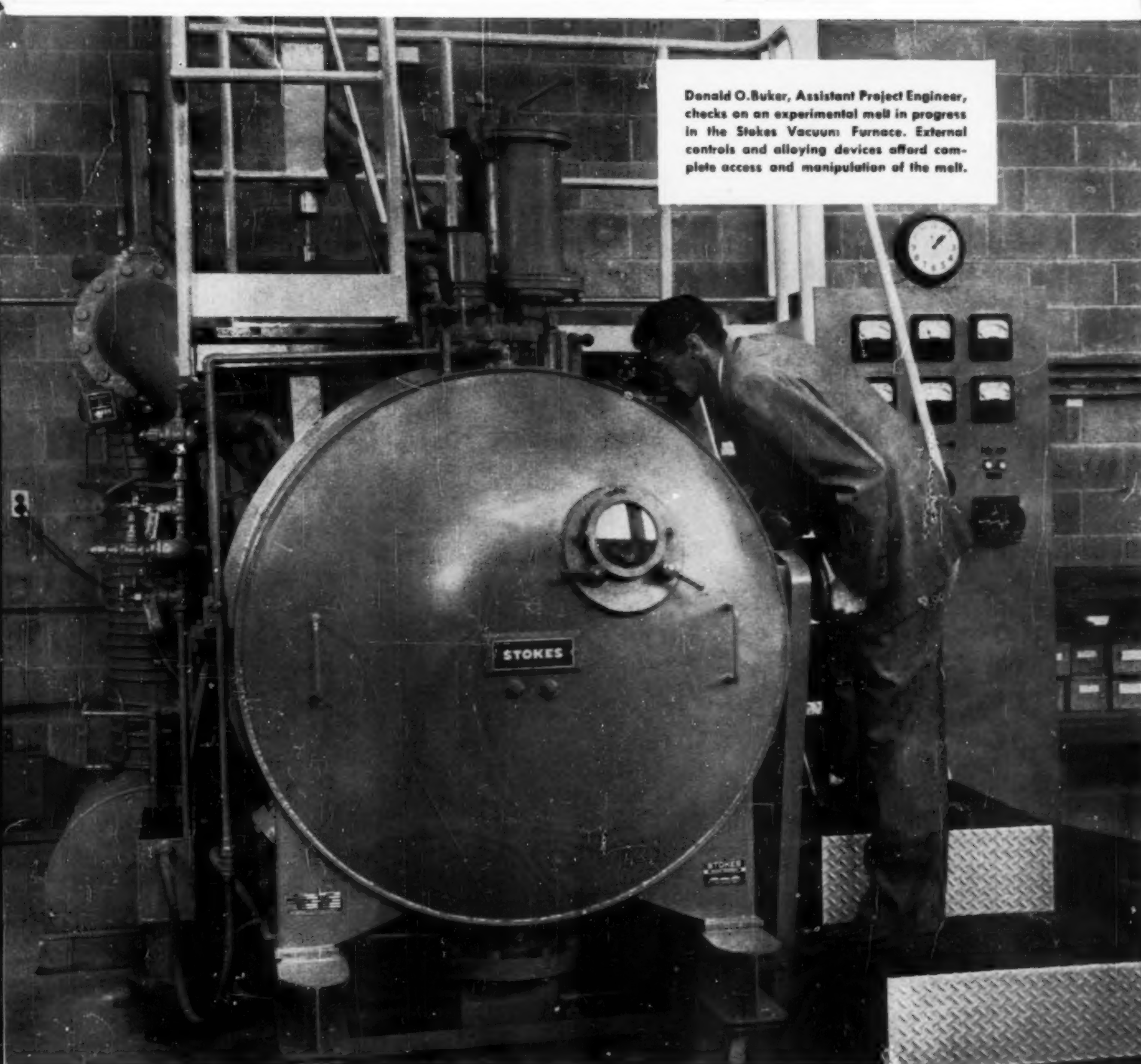
Thus each alloyed ceramic heating tube disperses heat by conduction and radiation from the superheated Flame-Busters. Heat is dispersed over a greater length within the tube. Localized overheating of the tube is impossible.

For electric operation, lift the Flame-Buster assembly from the ceramic tube, and replace it with a resistance type element. Changeover can be made quickly . . . and the elements are completely protected from the furnace atmospheres.

This cross section shows an assembly of Flame-Busters suspended in an Ipsen alloyed ceramic heating tube. Flame-Busters interrupt flame path, keep heat in tube longer, increase heat transfer.

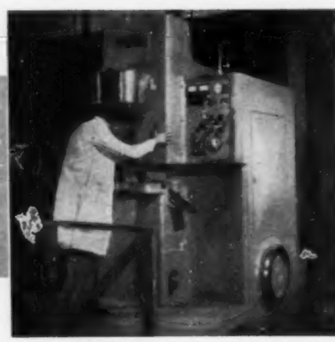
AUTOMATIC Ipsen HEAT TREATING UNITS

IPSEN INDUSTRIES, INC. · 723 S. MAIN STREET · ROCKFORD, ILLINOIS

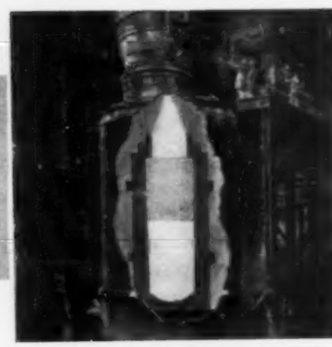


Donald O. Buker, Assistant Project Engineer, checks on an experimental melt in progress in the Stokes Vacuum Furnace. External controls and alloying devices afford complete access and manipulation of the melt.

THE METALS INDUSTRY IS PROFITING FROM THE USE OF OTHER STOKES PRODUCTION EQUIPMENT

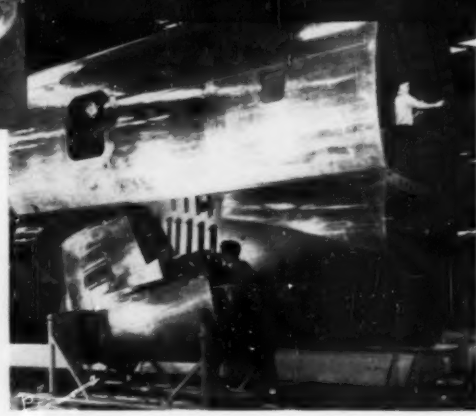


Powder Metal Presses. Cost savings and the compacting of incompatible alloys have made powder metallurgy an accepted process. Stokes offers the most complete line of presses in the industry.



Stream Degassing Systems. Stokes offers production equipment which can control hydrogen content of steel to less than 1 ppm by removing the gaseous impurities from the molten metal.

IN THIS *WONDERFUL*



Fabrication . . . The purchase and operation of metalworking machinery, equipment and supplies involves an engineering knowledge of metals. Engineering knowledge of metalworking, end product requirements, and metals, involve ME Factors that influence specifying and purchasing decisions. Only Metal Progress concentrates on providing engineering information for 29,058 Metals Engineers.

Design Application . . . ME Factors govern specifications for metal products. From thousands of sources and specifications for a tremendous variety of metals, ONE selection is most efficient, most economical. Extensive engineering knowledge of metals and processes provides the correct answer. Metal Progress and the American Society for Metals provide annually more than 100 million pages of Metals Engineering information.

NOW complete, authoritative records of hi-temp creep and stress-rupture tests

No longer need creep and stress rupture data be incomplete . . . inadequate. The Riehle testing machine can be furnished with high-temperature creep extensometer and Riehle-built autographic creep-time recorder. Accordingly, each test furnishes complete, authoritative information.

The Riehle Creep and Stress-Rupture Testing Machine is usually furnished with temperature controller, furnace, local wiring and other necessary components — fully ready to operate. Its design can accommodate a wide range of accessories and instrumentation to insure maximum versatility. This machine is the product of the very best in modern engineering technology and fabricating practice.

NEW 8-page bulletin describes "package" testing machine . . . instrumentation . . . accessories

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A DIVISION OF

American Machine and Metals, Inc.

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Please send free, your new 8-page Bulletin RR-13-56 containing full data on the "complete package" Riehle Creep and Stress-Rupture Testing Machine, instrumentation and accessories.

COMPANY

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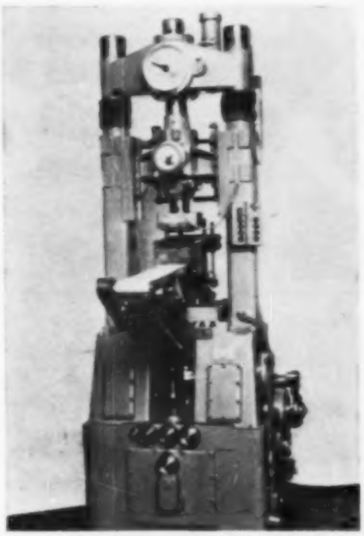
ATTENTION MR.

APPLICATION and EQUIPMENT new products

Powdered Metal Press

The Dorst Div. of Arnhold Ceramics Co. has announced a new multiple action 100 ton powdered metal press which is fully mechanical with hydraulic pressure indicators and 7 1/6 in. fill. Total height of the press is 11.8 ft. Controls are centrally lo-



cated and provide micrometer adjustment for floating die action, independent fill adjustments for tools with several fill levels, independent timing adjustment for compression from top and bottom, ejection adjustment. Positive stops support die, bottom punch and movable core rod during final compacting, thus assuring close dimensional control.

For further information circle No. 1 on literature request card, page 48-B.

High-Purity Aluminum

The United Mineral & Chemical Corp. has announced aluminum, 99.999% pure. This material was developed and is being produced by the Aluminum-Industrie A.G. of Switzerland. Properties claimed for the new metal include increased ductility, better light reflecting power, improved electrical conductivity and higher chemical stability. When anodized, optically purer oxide films result. Applications are in the fields of semi-conductors, catalysis and chemical analysis.

For further information circle No. 2 on literature request card, page 48-B.

Cleaners

Allied Research Products has announced new cleaners formulated to prepare zinc die castings and aluminum for Iridite coatings. Each cleaner is supplied in powdered form and is water soluble. Each contains water-conditioning, anti-foaming and anti-caking agents. The four cleaners consist of a zinc die cast cleaner, an aluminum etch cleaner, a non-etch cleaner for aluminum and an aluminum deoxidizer.

For further information circle No. 3 on literature request card, page 48-B.

Lab Furnace

Selas Corp. has announced a crucible furnace for small melts and for testing of small samples at temperatures up to 2650° F. Fired by any available fuel gas (natural, manufactured, mixed or LP) and air under low pressure, the crucible furnace will accommodate crucibles up to 15/16 in. base diameter by 2¼ in.

high. The design of the furnace is based on a similar production furnace used for melting dental metals and dip-welding wires.

For further information circle No. 4 on literature request card, page 48-B.

Welding

An integrated welding system using controlled atmosphere has been developed by L & B Welding Equipment, Inc. It occupies a floor area of

5 by 8 ft. and stands 6 ft. high. Internally, the welding chamber is 3 ft. in diameter and 4 ft. long. Six glove, two light, and four viewing ports are provided. All the controls are on a centralized composite pumping console. The system is designed for welding such metals as zirconium, titanium and complex stainless steel structures.

For further information circle No. 5 on literature request card, page 48-B.

Resistance Alloy

A new light-weight electric resistance alloy has been announced by the Kanthal Corp. The new material is an iron-chromium-aluminum alloy which retains strength and stability at temperatures to 1920° F. Melting point of Alkrothal 14 is 2750° F. and resistivity is 750 ohms per circular mil foot, measured at 68° F. It is available in both wire and ribbon in common sizes and has a specific gravity of 7.28.

For further information circle No. 6 on literature request card, page 48-B.

Heat Treating Basket

Stanwood Corp. has announced a new line of stacking baskets for handling parts through heat treating. Sides of the baskets are of corrug-

gated, rolled, heat-resistant alloy. The bottom grid, grid supporting base ring and the stacking ring at top are of high temperature cast alloy.

For further information circle No. 7 on literature request card, page 48-B.

Oven

A new series of mechanical convection ovens for laboratory, pilot plant study, and production has been announced by Blue M Electric Co. Air is mechanically convected horizontally across test specimen or production load by turbo blower and large ball-bearing motor. Heaters are at the top of oven, separated and shielded from the work chamber by a non-

radiant panel. The ovens, constructed of heavy gage steel, have a temperature range to 500 or 650° F. They have a capacity of 3.5 cu. ft.

For further information circle No. 8 on literature request card, page 48-B.

Thermocouple

Thermo Electric Co. has announced a new, high temperature thermocouple probe for use in the high velocity gas streams of jet engine after-

burners and ramjet and rocket exhausts. It will operate at temperatures as high as 3600° F. Platinum 6% rhodium/platinum 30% rhodium conductors are used up to 3000° F. and iridium/iridium rhodium up to 3600° F.

For further information circle No. 9 on literature request card, page 48-B.

Balance

A new one-pan analytical balance for weighing from 0.1 milligram to 200 grams has been announced by the Christian Becker Div. of the Torsion Balance Co. It has a two-beam construction. Weighings from

1 to 200 grams, are made to within 1 gram on a rough-weighing beam. Weighing adjustments from 0.1 milligram to 1 gram are made automatically on a fine-weighing beam. This two-beam construction reduces knife edge wear on the fine-weighing beam and prolongs the accuracy of the balance. The balance is temperature-compensated.

For further information circle No. 10 on literature request card, page 48-B.

Moisture Control

A new electrolytic moisture analyzer which will automatically measure, record and control moisture contents of treating gases down to 1 p.p.m. has been announced by Manufacturers Engineering & Equipment Corp.

For further information circle No. 11 on literature request card, page 48-B.

Transfer Unit

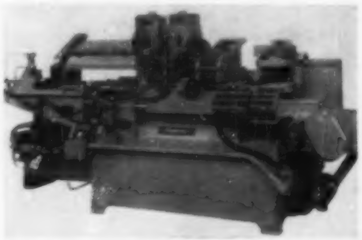
A new, portable transfer unit which will convert three standard stamping presses into a continuous automated production line has been announced by Sheffield Corp. Aluminum transfer rails with retractable pickup fingers move back and forth to transfer stampings from one press to another. Transfer distance can be adjusted from 8 in. to 3 ft. or more. Pickup fingers are interchangeable to accommodate stampings of different shapes and sizes. The reciprocating

motion of the transfer rails is imparted by a drive unit located between the nearest and middle presses shown on page 25. An electric motor in the base of the unit drives two cams to obtain the transfer motion.

For further information circle No. 12 on literature request card, page 48-B.

Welder

An automated flash welder which resistance flash welds worms to ends of automotive steering gear shafts has been announced by the Federal Machine & Welder Co. Both parts are automatically fed from loading



chutes, injected against a gage bar for correct weld position, and ejected after welding. Marking device for shaft and radial positioner for worm are incorporated in the automatic sequence. The welder incorporates a 150 k.v.a. transformer.

For further information circle No. 13 on literature request card, page 48-B.

Atmosphere Furnaces

A new line of controlled atmosphere electric furnaces for use to 2000° F. has been announced by the L & L Mfg. Co. The furnaces are complete with Inconel muffle and atmosphere generator employing a patented process using alcohol as one of

the possible atmosphere generating liquids. Varying the proportions of alcohol and distilled water, plus the cracking unit temperature permits adjustment of the proportions of H_2, CH_4, CO to suit the type of steel and heating process. There are six standard models.

For further information circle No. 14 on literature request card, page 48-B.

Titanium Fittings

Ladish Co. has announced a line of titanium fittings to meet the needs of nuclear piping systems and in chemical processing industries. Fittings resist attack by corrosive salts at moderate temperatures, and provide greater latitude in tensile strength, fatigue resistance and ductility under a wide range of conditions.

For further information circle No. 15 on literature request card, page 48-B.

Potentiometer Recorder

A new strip chart potentiometer recorder has been announced by West Instrument Corp. Free of vacuum tubes, it operates without warm-up. It uses printed circuits and transistors in its amplifier. The Marksman

features full selection of scale ranges and chart speeds. It will record any variable that can be transformed into an electric signal through transducers and operates at 115, 208, or 230 volts.

For further information circle No. 16 on literature request card, page 48-B.

Oxygen Analyzer

A self-contained O_2 test unit for on-the-spot boiler and furnace test work has been announced by Leeds & Northrup. The equipment operates at temperatures between 32 and 120° F., and from any standard 115 volt, 60 cycle power source. Analyzing and recording is accomplished by conventional L&N instruments—a magnetic O_2 analyzer and a speedomax G recorder. Five-in. rubber tired casters facilitate moving the assembly over rough flooring.

For further information circle No. 17 on literature request card, page 48-B.

Cleaning Gases

The Process Equipment Div. of Automotive Rubber Co. has announced new gas scrubbing systems. They are available in two types of

designs: the Cyclonic jet type to

the Bal-Tate Furnace Co. Originally

Specify SANDVIK

Precision-Tailored

Spring Steel

FOR ACCURATE FLATNESS, STRAIGHTNESS, WIDTH, GAUGE AND EDGE FINISH *PLUS* SPECIFIC PHYSICAL PROPERTIES

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From composition, through processing to the finished strip, Sandvik has had long experience in precision-control. That is why you find Sandvik steels used for feeler gauges, watch springs, compressor valves, camera shutters, reeds, shock absorbers and many other exacting spring steel applications.

Sandvik supplies cold rolled specialty strip steels —

- **In special analyses for specific applications.**
- **Precision-rolled thicknesses to fit your requirements.**
- **In straight carbon and alloy grades.**
- **Annealed, unannealed or hardened and tempered — scaleless or polished bright, yellow or blue.**
- **With square, round or dressed edges.**

Sandvik stocks a wide variety of qualities and sizes. In addition Sandvik has Rolling, Slitting, Edge-Filing and Hardening and Tempering facilities.

NEW, FREE BROCHURE

Gives Specific Data On Sandvik Cold Rolled and Hardened and Tempered Strip Steels. Catalogs leading types by application and lists finish, usual size range and chemistry. Send for your copy today.

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SS-138

Sandvik's Quality Steels

designs: the Cyclonic jet type to handle dust and liquid aerosols which are micron in size or larger and the jet Impactor type to handle fumes, fogs and mists which are submicron in size, particles developed from chemical or metallurgical operation where a change of physical state occurs as around nonferrous reverberatory and blast furnaces and ferrous blast furnaces and cupolas. Sizes of scrubbing systems range from 500 to 20,000 c.f.m. capacity.

For further information circle No. 18 on literature request card, page 48-B.

Compacting Press

A new 125-ton powdered metal compacting press has been announced by Haller, Inc. and the Watson-Stillman Div. This press has one pressing motion from the top, one pressing and one ejection motion from the bottom. Dual concentric cylinders are employed at the bottom of the press. The outer cylinder supplies bottom compacting

pressure and the inner cylinder is for ejection. Stroke of both cylinder rams is adjusted and locked externally. The lower compression stroke can be locked out of operation with the ejection cylinder operating normally when it is desirable to press from the top only. Timers and controlling valves are placed in front and on the control panel. The machine frame, controls, and hydraulic system have been placed on one base so that the unit is easy to move in place and no pit is required under the press.

For further information circle No. 19 on literature request card, page 48-B.

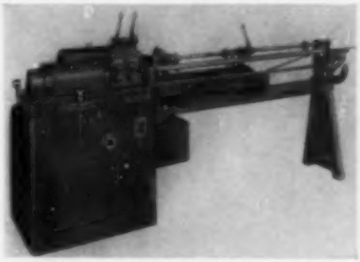
Furnace

A new heating furnace, embodying the use of liquid glass as a heating medium, has been announced by the Bal-Tate Furnace Co. Originally built and introduced in Italy, the furnace will handle the heating of ingots prior to extrusion, using liquid glass in a revolving drum chamber as the heating medium.

For further information circle No. 20 on literature request card, page 48-B.

Wire Straightening and Cutting

The Lewis Machine Co. has announced a new series of wire straightening and cutting machines. These new machines are equipped with variable speed drives for feed speed up



to 200 fpm. and dual-center rotary straightener arbors. They can handle round wire, 0.012 to 1 in. in diameter, and can be converted to handle shapes, hex or flats by installing the interchangeable roll straightener.

For further information circle No. 21 on literature request card, page 48-B.

Cleaning Solvent

A new cleaning solvent for wipe or dip cleaning of greasy and oily machine parts and electrical equipment has been announced by Harco Chemical Co. It replaces carbon tetrachloride and other chlorinated solvents and has no flash point under normal usage. It has high solvent power with rapid evaporation.

For further information circle No. 22 on literature request card, page 48-B.

Salt Bath Furnace

Lucifer Furnaces has announced new salt bath furnaces in 10 sizes with heat ranges to 1700° F. All models are complete with controls.

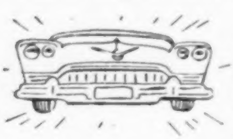
For further information circle No. 23 on literature request card, page 48-B.


FOR SALE
Commercial-grade zirconium sponge
(hafnium-containing)
Commercial-grade zirconium is now for sale in tonnage quantities — from Columbia-National in sponge form or as rod, sheet and tubing from the country's leading mills.
You can put commercial-grade zirconium to work:
• To combat severe corrosion in the process industries.
• For prototype or experimental work in the nuclear energy field.
To help you investigate and use zirconium, Columbia-National offers experienced technical assistance on melting, fabricating and alloying.
New Technical Digest now ready! Write for data on properties and applications of commercial-grade zirconium.
NEW METALS FOR INDUSTRY
Columbia-National Corporation
Jointly owned by Columbia-Southern Chemical Corporation and National Research Corporation
Dept. C 4-C — 70 Memorial Drive, Cambridge, Mass.

Any similarity to a real-life company is purely intentional

How did they use their beans in Boston to cut forming rejects?

A couple of years ago, Otto Motive, super sales engineer of East Boston, Mass., began to eye a new prospect.



Thought he, "As an account, that Supercrate V-8 looks great. They buy a lot of parts. It sure would be peachy—and profitable—to land that plum!"

And, by golly, Otto did get a contract — to furnish wire-wheel units of 25-gauge stainless.

He also got *more* than he bargained for. Sleepless nights, for example. Because — though tempus fugited, production of the wire-wheel units didn't.

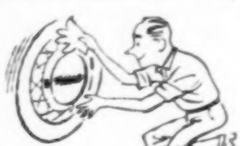
It seems that the boys in Otto's shop had trouble forming the hub-cap sections of the units. The stainless scored in the die. Rejects piled up. The scrap pile became something to behold. Delayed delivery dates caused delirium.

Then someone suggested trying dies made from Ampco Metal Grade 24 (a just cause for a raise, if we've ever heard of one!).

Rejects dropped off to practically nothing. Which is no surprise to us. Dies made from Ampco Metal have done as much for many a shop drawing or forming stainless or other clean metals—have made possible real savings.

And they can do as much for *you*. You can count on that!

Ampco Metal dies have an exceptionally low coefficient of friction. They don't load, gall, or scratch the work. They hold close tolerances longer.



You make a better product with fewer costly finishing operations. You cut scrap loss.

You reduce downtime, also. Ampco Metal dies have little or no pickup — you get far longer runs than with steel dies without redressing.

An Ampco stocking distributor near you carries 70 sizes of Ampco Metal die blanks — solid rounds, rectangles, and centrifugally cast rings. Call him.

AMPCO ®

If you don't know who your Ampco distributor is, write us for his name. *Ampco Metal, Inc., Dept. MP-1, Milwaukee 46, Wisconsin. (West Coast Plant: Burbank, California).*

AMPCO METAL

The metal without an equal

RM-6

APPLICATION and EQUIPMENT new literature

30. Abrasive Cleaning
Folder on Malleabrasive for airless blast cleaning equipment gives advantages, grades, equipment it may be used with and parts that may be cleaned. *Globe Steel Abrasive*

31. Abrasive Cutting
Bulletin DH-460-B on machine models and capacities. *Campbell Machine Div.*

32. Air Washers
Bulletin No. 256 on acid-proof air washers for ventilation systems. Construction and accessories. *Automotive Rubber*

33. Alloy Castings
8-page bulletin on alloy castings for heat treating. *Ohio Steel Foundry*

34. Alloy Steel
40-page book on applications of heat treated, special alloy steel. *Jones & Laughlin*

35. Aluminum Die Castings
Bulletin on design and manufacture of aluminum die castings. *Hoover Co.*

36. Aluminum Extrusions
Folder lists alloys used, finishes, trade phraseology. *General Extrusions, Inc.*

37. Arc Welding
60-page booklet on how to get better welds. Metals and electrodes, proper procedures, types of joints, typical positions, welding symbols. *Hobart Bros.*

38. Atmosphere Furnace
4-page bulletin on automatic continuous heat treating furnace. Operational advantages, principle of operation, capacity, construction. *American Gas Furnace Co.*

39. Atmosphere Furnace
Bulletin HD-1 on batch-type controlled atmosphere furnace. Specifications, atmosphere circulation. *Dow Furnace Co.*

40. Batch-Type Furnaces
Bulletin SC-174 on furnaces in the operating range of 1400 to 1750° F. for various heat treating processes. Suction radiant tube fired units and mechanized systems. *Surface Combustion*

41. Bending Machines
New 30-page book on how to bend, equipment, shapes and how each is made. *O'Neil-Irwin Mfg. Co.*

42. Bolts
16-page booklet on high-strength bolting for structural joints includes ASTM specifications covering this bolting material. *Bethlehem Steel*

43. Brazing
8-page reprint on dip brazing of aluminum assemblies. Design of parts, equipment used, maintenance, tooling. *Ajax Electric*

44. Brazing
8-page bulletin S-1050 on production brazing and soldering with automatic machines. Custom models. *Selas*

45. Brazing
How high-temperature honeycomb structures are brazed, printed in Low-Temperature Brazing News, No. 77. *Handy & Harman*

46. Brazing Aluminum
Bulletin 23 on dip brazing method for aluminum. Step-by-step procedures, design techniques, fixturing arrangements. *Handy & Harman*

47. Carbon Brick
Bulletin on properties, grades, applications of carbon and graphite brick for handling corrosive chemicals and molten metals. *National Carbon*

48. Carbon Control
16-page bulletin on equipment for carbon and sulphur determination, including combustion furnaces and other accessories. *Harry W. Dietert*

49. Carburizer
Data sheet on Perliton 400, water soluble carburizer. Operation of bath. Case depths. *E. F. Houghton & Co.*

50. Castings
Bulletin 3150-G on castings for heat, corrosion, abrasion resistance. *Duraloy*

51. Castings
16-page booklet on gray iron, ductile iron, special iron and steel castings. Physical property data. *Howard Foundry Co.*

52. Castings
20-page catalog 57 on casting aluminum and magnesium. Patterns, alloys cast. *Wellman Bronze & Aluminum Co.*

53. Centrifugal Castings
8-page brochure gives properties of most common grades of thermalloy centrifugally cast tube. Weight tables. *Electro-Alloys Div.*

54. Chain
4-page bulletin DH-101 on sling chains. Selection, working loads. *American Chain*

55. Chemicals
22-page bulletin on industrial chemicals lists those available and illustrates their manufacture and testing. *Harshaw Scientific*

56. Chromate Finishing
File on chromate conversion coatings for prevention of corrosion and paint-base treatment of nonferrous metals. *Allied Research Products*

57. Cleaning and Finishing
12-page bulletin 68 on equipment for metal cleaning and treating describes two-stage, 3-stage and multiple-stage washers and washer heating systems. *Despatch Oven Co.*

58. Coated Metals
New bulletin on roll coating shows how it is done and includes samples. *Roll Coater, Inc.*

59. Coatings
4-page catalog on heat-proof protective coatings. Basic types, applications, methods of applying and temperature ranges. *Markal Co.*

60. Cold Forming
4-page folder on die-form process for cold reduction of steel bars into multi-diameter shaft blanks for finish turning or grinding. *Republic Steel*

61. Compressors
12-page bulletin 126-A on application of turbo compressors to oil and gas-fired equipment used in heat treating, agitation, cooling, drying. Performance curves, capacities. *Spencer Turbine*

62. Controlled Atmospheres
Bulletin on Dewpointer for reading of atmosphere in field and laboratory. Readily portable, operating on a.c. or enclosed battery. *Illinois Testing Labs.*

29. Corrosion of Copper

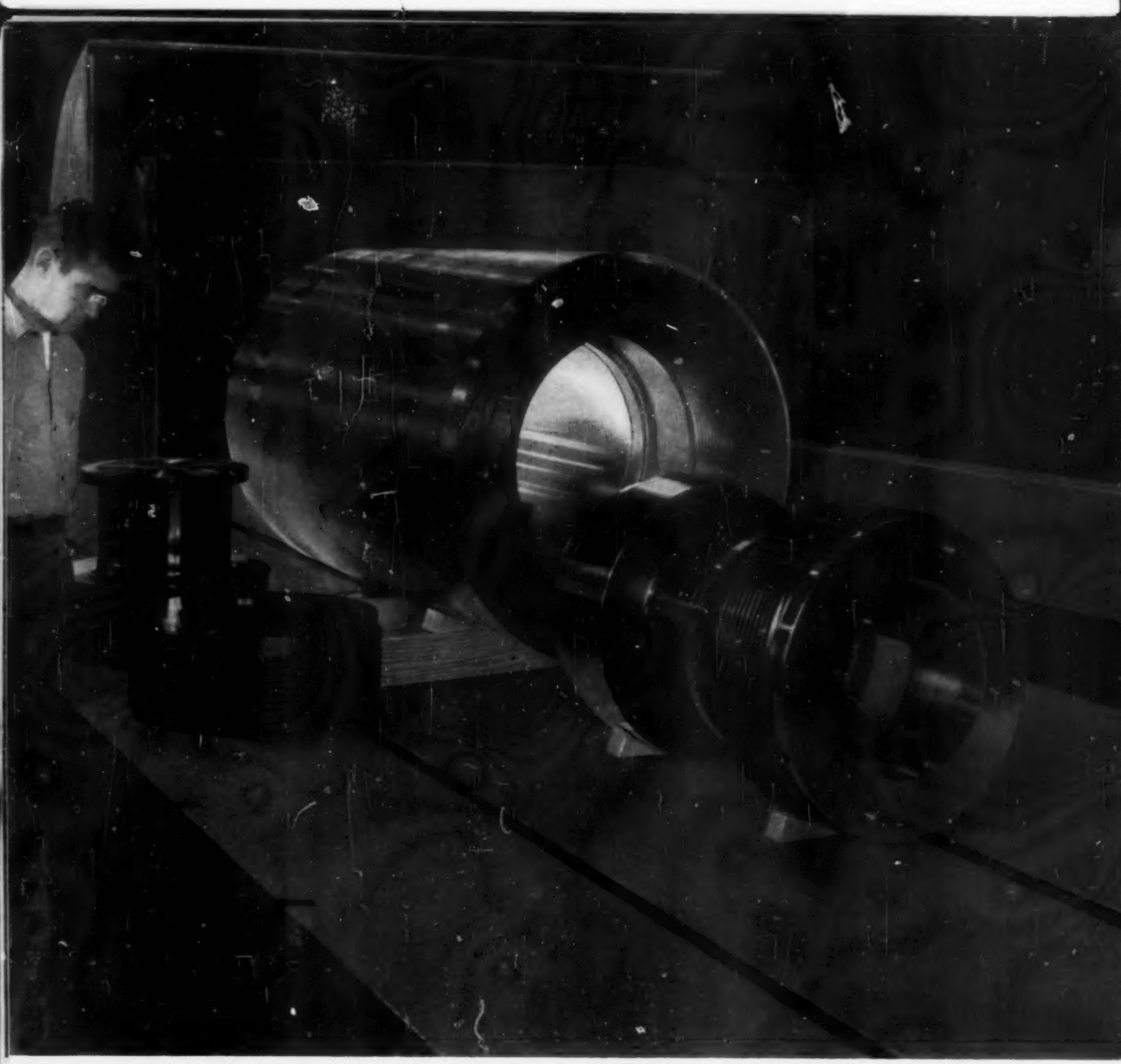
This 32-page reference booklet was written to help the materials engineer in selecting the copper alloy best suited for a particular corrosive condition. Following a discussion of the theory of corrosion and types of

corrosive attack is a general discussion of the resistance of copper alloys to various atmospheres, acids, alkalies, sea water, petroleum and other mediums. A corrosion chart rates copper, low and high zinc brass, special brasses, phosphor and aluminum bronze, copper-silicon alloys, cupronickel and nickel silver for service involving 187 applications. Compositions and properties of copper alloys and welding rods conclude the booklet. *American Brass Co.*

63. Conveyors
Bulletin MF-200 on conveyor standardization describes prefabricated sections for making customized conveyors. *May-Fran Engineering*

64. Coolant
8-page booklet on oilless coolant, lubricant and rust preventive. Advantages. *Harry Miller Corp.*

65. Copper Alloys
60-page catalog on phosphor bronzes, nickel silvers, beryllium copper, cupronickel. Chemical and physical data. Engineering tables. *Riverside-Alloy Metal*



AT WHITE PINE COPPER MINE

66. Corrosion
Data sheets on caustic embrittlement, galvanic corrosion. *Chemical Plants Div., Blaw-Knox Company*

67. Corrosion Resistance
20-page bulletin on copper alloys for corrosion resistance. Table gives applicability in 150 media. *Ampco*

68. Cutting Tools
36-page booklet analyzes and compares carbon, high speed, cast alloy and carbide tool materials. *Allegheny Ludlum*

69. Cutting Tools
12-page catalog D-56 on aluminum oxide cutting metals, tool tips, throw-away inserts, cylinders and other machine turning and cutting tools. *Metal Carbides*

70. Decarburization
8-page booklet on effects of decarburization on tool steels tells what it is and what can be done about it. *Carpenter Steel*

71. Degreaser
Folder on automated degreaser. Cleaning and solvent cycles described. Features of equipment. *Detrex*

72. Degreasers
Folder on vapor and solvent degreasers describes equipment and advantages. *Randall Mfg.*

73. Degreasing
Bulletin on OPNT vapor degreaser describes and diagrams its construction. *Circo Equipment*

74. Degreasing
40-page book on trichlorethylene gives specifications, properties, uses, handling and storage, toxicity and safety measures. *Hooker Electrochemical Co.*

75. Die Casting
New edition of 32-page pocket-book on zinc die castings. Factors affecting soundness, common defects. *Henning Bros. & Smith*

76. Die Castings
20-page reprint of findings of 31 European experts on die casting industry. Machines, die design and construction, metallurgy, foundry practice. *Apex Smelting Co.*

77. Diffractograph
4-page bulletin on electron diffractograph. Operation, applications, accessories. *New England Scientific Instruments*

78. Dryers
Bulletins D-102 and D-103 on steam and electric reactivated air and gas dryers. Flow diagrams, operation. *C. M. Kemp*

79. Ductility Testing
New bulletin on simple method of determining ductility of materials before drawing. *Steel City Testing Machines*

80. Electric Furnaces
Bulletins on furnaces for all types of heat treating and hardening, both standard and custom. *Pacific Scientific Co.*

81. Electric Furnaces
Bulletin No. 528 on electric furnace for investment casting. Weight of charge, melt time, power consumption for stainless, Stellite, gray iron, copper, brass. *Detroit Electric Furnace Div.*

82. Electric Furnaces
Bulletin on electric heat treating furnaces gives summary of progress in furnace developments. *Holcroft*

83. Electric Furnaces
8-page Bulletin 570 on heat treating, melting, metallurgical tube, research and sintering furnaces. *Pereny*

84. Electric Heating
4-page bulletin on electric heating elements for pipe, tube and tank heating. Sizes, temperature control, element life

AT WHITE PINE COPPER MINE

USS "T-1" Steel consistently outperforms other materials*

*Feeder chute liners last 2 to 3 times longer

Hard and flinty copper ore plays hob with ordinary materials. That's why virtually all the feeder and transfer chutes in White Pine's crushing plant are now lined with USS "T-1" Steel. Quenched and tempered to 321 minimum Brinell, USS "T-1" Steel liners, ⅜" thick, have proved far longer-lasting than materials formerly used, and they give from 2 to 3 times longer service. These USS "T-1" Steel liners are easy to fabricate, are readily flame-cut to size—a great advantage over cast, anti-abrasive materials.

*Loader plates last 8 to 12 months longer

At White Pine Copper, USS "T-1" Steel supplied to 321 minimum Brinell, is used in the bottom and side plates of the conveyor of this loading machine. Also in the plates on its underside along which the returning conveyor chain slides. Prime requirements here are toughness and high resistance to impact abrasion. Every one of these underground loaders has been overhauled since the mine was opened and, in every case, USS "T-1" Steel has been used to increase durability. The result—8 to 12 months more service life. White Pine maintenance men report "T-1" Steel easier to flame-cut and weld than other steels used for this particular application.

WHITE PINE COPPER'S experience with USS "T-1" Steel is typical of the improvements in service that this remarkable steel makes possible. Wherever they have used it to replace former construction, equipment life has been materially increased. Repair and maintenance costs have been cut. Down time has been reduced. All this means savings in time and money—savings that are far greater than the difference in initial steel cost.

Here's why USS "T-1" Steel can help improve your equipment

When you want strength far beyond the ordinary, you can get it with USS "T-1" Steel—for with a minimum yield strength of 90,000 psi and a minimum tensile strength of 105,000 psi, USS "T-1" Steel is nearly three times as strong as structural carbon steel. This is far higher yield strength than has ever before been available in weldable plate steel. What's more, its strength is not lowered by welding or gas cutting.

For equipment subject to impact abrasion, USS "T-1" Steel can be obtained quenched and tempered to a minimum hardness of 321 Brinell. Even this very hard grade can be welded and flame-cut *right in the field* without pre-heating. That means you don't have to shut down costly, high-capacity equipment for the many hours generally required for shop repairs.

If your equipment must withstand severe impact abuse, USS "T-1" Steel insures against damage in winter weather. Whether furnished to 321 minimum Brinell or to 90,000 psi minimum yield strength, it has exceptional toughness and resistance to brittle failure, even at temperatures far below zero.

Our new catalog—USS "T-1"—is complete with technical information and offers many practical suggestions for its use that can save *you* money. For your free copy, write to United States Steel Corporation, Room 2801, 525 William Penn Place, Pittsburgh 30, Pa.

United States Steel Corporation, Pittsburgh · Columbia-Geneva Steel Division, San Francisco
Tennessee Coal & Iron Division, Fairfield, Ala. · United States Steel Supply Division, Warehouse Distributors, Coast-to-Coast
United States Steel Export Company New York

USS "T-1" CONSTRUCTIONAL ALLOY STEEL

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UNITED STATES STEEL

and installation discussed. *Cooley Electric Mfg. Corp.*

85. Electroplating
36-page book gives 28 simple methods of analyzing plating solutions. Tables on reactions of acids and alkalies with metals, electrochemical data. *Hanson-Van Winkle-Munning*

86. Electroplating
Bulletin on electroplated gold, rhodium, palladium, platinum, silver, nickel, and analysis of gold and gold alloy solutions. *Technic*

87. Extrusions
Bulletin on extruded seamless alloy and stainless steel tubing. Properties, shapes. *Metals Processing Div., Curtiss-Wright*

88. Fasteners
52-page catalog of stainless fasteners. Thread and design specifications. Composition and properties of steels used. *Allmetal Screw Products Co.*

89. Forging Machinery
32-page book No. 165 on design of dies for upsetting forging machines also includes machines, representative parts, tables of decimal equivalents and areas of circles. *Ajax Mfg. Co.*

90. Forgings
12-page booklet on how forged weldless rings and flanges are made. Case histories. *Standard Steel Works Div., B-L-H*

91. Forgings
94-page book on die blocks and heavy-duty forgings. 20 pages of tables. *A. Finkl & Sons*

92. Forgings
16-page booklet shows how forgings are made, sizes and tolerances. *McInnes Steel*

93. Forgings
Bulletin on forge steelmaking, open die forging, machining, heat treating and finishing. *National Forge*

94. Forgings
12-page bulletin includes data on design of forgings, advantages of forgings, typical examples. *Pittsburgh Forgings Co.*

95. Forgings
New folder on facilities for production of flat-die forged products. Electronic equipment used. *Smith-Armstrong*

96. Formed Shapes
26-page catalog No. 1555 contains drawings and dimensions of more than 100 shapes. *Roll Formed Products Co.*

97. Forming
86-page book on equipment and process of cold roll-forming. Wide sheets, narrow trim, tubular shapes, curving, coiling, tooling needed. *Yoder*

98. Furnace
Article on car-type furnace for heat treating castings at General Railway Signal Co. in Metal Minutes, June 1957. *Sunbeam*

99. Furnaces
Bulletin No. 461 on gas, oil and electric furnaces. 17 different installations described. *Electric Furnace Co.*

100. Furnaces
Lists of surplus furnaces for sale. *Joe Martin Co.*

101. Furnaces
Folder giving drawings, dimensions, capacity, Btu. required for drawing, annealing, forging. *Gas Machinery*

102. Furnaces
Data on radiant aluminum die casting furnaces. *J. A. Kozma Co.*

103. Furnaces
Catalog on standard and special furnaces and ovens to 3000° F. *L & L Mfg.*

104. Furnaces
16-page bulletin 135 on industrial furnaces and atmosphere generators. Continuous systems. *Continental Industrial Engineer*

105. Furnaces
High-temperature furnaces for temperatures up to 2000° F. are described in bulletin. *Carl-Mayer Corp.*

106. Graphite
4-page catalog section S-5050 on impervious graphite and resin-base cements for corrosive service. 2-page table gives recommendations for commercial applications. *National Carbon*

107. Hardness Conversions
Desk-size chart of conversions for Rockwell tests and other hardness scales. *Torsion Balance Co.*

108. Hardness Tester
20-page book on hardness testing by Rockwell method. *Clark Instrument*

109. Hardness Tester
Bulletin A-16 on micro-reflex hardness testers. Loads to 3000 gr. Zeiss optical system. *Gries Industries, Inc.*

110. Hardness Tester
Bulletin on how to test large gears with portable Brinell tester. *King Tester Co.*

111. Hardness Tester
Data on portable hardness tester with Rockwell and Brinell scales. *Mechanical Devices*

112. Hardness Tester
4-page bulletin on portable metal hardness tester for any shape or metal. Ranges, features. *Newage Industries*

113. Hardness Tester
Catalog 72-1 on Leitz miniload tester for Vickers and Knoop hardness tests. *Opto-Metric Tools, Inc.*

114. Hardness Tester
Data on hardness testing scleroscope with equivalent Brinell and Rockwell C numbers. *Shore Instrument*

115. Hardness Testers
Catalog of testers for normal hardness, superficial testing, accessory and special testing and micro and macro hardness testing. *Wilson Mechanical Instrument*

116. Heat Treat Pots
Catalog on pressed steel pots for lead, salt, cyanide, oil tempering and metal melting. *Eclipse Industrial Combustion*

117. Heat Treating
12-page bulletin on design advantages, sizes of tool steel atmosphere furnaces. Endothermic atmosphere generators. *C. I. Hayes, Inc.*

118. Heat Treating
20-page catalog on the Homocarb method with Microcarb atmosphere control for heat treatment of steel. *Leeds & Northrup*

119. Heat Treating
Monthly bulletin on used heat treating and plating equipment, available for immediate delivery. *Metal Treating Equipment Exchange*

120. Heat Treating
Bulletin describes baskets, crates, trays, furnace parts for heat treating. *Stanwood*

121. Heat Treating
Bulletin 14-T on ovens for heat treatment of aluminum and other low-temperature processing. *Young Bros.*

122. Heat Treating Ammonia
24-page "Guide for Use of Anhydrous Ammonia" describes heat treating and other metallurgical uses. *Nitrogen Div.*

123. Heat Treating Belts
Catalog of conveyor belts and data for their design, application and selection. *Ashworth Bros.*

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BETTER RECOVERY

...of manganese with MANTEMP ferromanganese

This new exothermic manganese alloy allows open hearth melters to make higher additions of manganese to the ladle (up to 1.5% manganese). Thus you get:

- 10% to 15% higher recoveries of manganese.
- More consistent manganese recoveries with fewer missed heats.
- 15 to 20 minutes less furnace time for low-carbon heats.

The strong exothermic action of MANTEMP ferromanganese sharply reduces segregation of manganese within the ladle. In addition, its unique exothermic reaction allows higher and more consistent recoveries of aluminum when aluminum is added as an alloying element.

Your nearest ELECTROMET office will be glad to give you further information concerning the high and medium-carbon grades of MANTEMP exothermic ferromanganese. Write ELECTRO METALLURGICAL COMPANY, Division of Union Carbide Corporation, 30 E. 42nd St., New York 17, N.Y.

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Electromet

FERRO-ALLOYS AND METALS

UNION CARBIDE

The terms "Electromet", "Mantemp" and "Union Carbide" are trade-marks of Union Carbide Corporation.

124. Heat Treating Belts
New 16-page booklet on selection of steel processing conveyor belts gives complete specifications. *Colorado Fuel & Iron Corp., Wickwire Spencer Steel Div.*

125. Heat Treating Fixtures
4-page folder on retorts, baskets, trays, carburizing boxes, fans for heat treating. *Aluminum & Architectural Metals Co.*

126. Heat Treating Fixtures
Folder on carburizing boxes, trays, heat treat fixtures and baskets. *Misco*

127. Heat Treating Fixtures
24-page catalog on heat and corrosion-resistant equipment for heat treating and chemical processing. 30 classifications of equipment. *Pressed Steel*

128. Heat Treating Fixtures
New 32-page catalog G-10A lists process equipment, heavy welded fabrications, muffles, trays, fixtures for furnaces, heat-treating equipment, pickling equipment. *Rolock*

129. Heat Treating
Folder on industrial furnaces. Continuous designs. Insulation. *Pacific Industrial*

130. Heat Treating Pots
Bulletin 110 gives data on sizes and shapes of cast nickel-chromium solution pots. *Fahralloy*

131. Heating Element
New 12-page catalog on 35-20 nickel-chromium-iron heating element. Temperature-resistance curve, physical property tables and factors to consider in designing furnace elements. *Hoskins Mfg. Co.*

132. Heating Elements
24-page booklet on elements for electric furnaces and kilns includes technical data, uses, physical and electrical specifications. *Norton*

133. High-Temperature Alloy
Bulletin 106 gives data on Type 321 stainless and contains temperature range chart for six alloys. *Rolled Alloys*

134. High-Temperature Alloy
New 28-page book on Hastelloy X, nickel base alloy. Property data, welding, machining, forging. *Haynes Stellite*

135. High-Tensile Steel
8-page bulletin on properties and composition of N-A-X high-tensile steel. Examples of resistance to impact, fatigue, abrasion and corrosion. *Great Lakes Steel*

136. Impact Testing
Bulletin on machine for Izod, Charpy and tension testing. *Riehle*

137. Induction Brazing
Folder tells how tips of carbide may be brazed on tool shanks. *Ohio Crankshaft*

138. Induction Heating
Induction Heating News No. IHN-7 describes applications of induction heat in heat treating of metals. *Induction Heating Corp.*

139. Inoculant
New 96-page booklet on SMZ alloy, an inoculant for cast iron. Metallurgical aspects of inoculation. How to inoculate irons. *Electro Metallurgical Co.*

140. Lab Test Dies
Complete information on multi-motion laboratory test specimen dies. *Haller*

141. Laboratory Equipment
12-page catalog on high-frequency induction combustion units and accessories for carbon, sulphur and hydrogen analysis. *Lindberg Engineering Corp.*

142. Laboratory Furnace
Data on nonmetallic resistor furnaces for research, testing or small-scale production. *Harrop Electric Furnace*

143. Laboratory Furnace
Bulletin RT-10 on 25 lb. per hr. laboratory metal treating unit for carburizing, hardening, carbonitriding, brazing, carbon restoration. *Ipsen*

144. Laboratory Furnaces
Folder describes and illustrates tubular furnace for use in tensile testing, and control panels. *Marshall Products*

145. Leaded Steels
16-page booklet on basic characteristics, mechanical properties and workability of leaded steels. Case histories. *Copperweld Steel Co.*

146. Low-Alloy Steel
60-page book on high-strength low-alloy steel, properties, fabrication and uses. *U. S. Steel*

147. Lubricant
Bulletin 103A on fringe area lubrication with molybdenum disulfide lubricants for extreme bearing pressures and all temperatures. *Alpha Molykote*

148. Lubricants
List of colloidal and semi-colloidal dispersions. Carriers, diluents, applications of each. *Acheson Colloids*

149. Lubricants
8-page booklet on colloidal greases, forging compounds, hydraulic concentrate and others. *Grafo Colloids*

150. Magnesium
42-page booklet on wrought forms of magnesium. Includes 31 tables. *White Metal Rolling & Stamping*

151. Malleable Iron
Reprint 51-B on metallurgy, treatment and heat treated properties of malleable iron. *Surface Combustion*

152. Marking Machines
Data on various types of marking machines from bench mounted machines for light duty marking to machines capable of marking at up to 6 tons table pressure. *Jas. H. Matthews & Co.*

(*Continued on page 48-A*)

XXV

This is the twenty-fifth of a series of advertisements dealing with basic facts about alloy steels. Though much of the information is elementary, we believe it will be of interest to many in this field, including men of broad experience who may find it useful to review fundamentals from time to time.

Thermal Stress-Relieving of Alloy Steels

In the production of alloy steel bars and parts made of alloy steel, stresses are sometimes set up, and these stresses must be relieved before optimum results can be expected. Two general types of stress-relieving are practiced—thermal and mechanical. In this discussion we shall consider only the former.

There are several important reasons for thermal stress-relieving. Among these are the following:

(1) The first and most fundamental purpose is to reduce residual stresses that might prove harmful in actual service. In the production of quenched and tempered alloy steel bars, machine-straightening is necessary. This induces residual stresses in varying degrees. Bars are usually stress-relieved after the straightening operation. When the bars are subjected to later processing that sets up additional stresses, subsequent stress-relieving may be necessary.

(2) A second major purpose of thermal stress-relieving is to improve the dimensional stability of parts requiring close tolerances. For example, in rough-machining, residual stresses are sometimes introduced, and these should be relieved if dimensional stability is to be assured during the finish-machining.

(3) Thermal stress-relieving is also recommended as a means of restoring mechanical properties (especially ductility) after certain types of cold-working. Moreover, it is required by the "safe-welding" grades of alloy steels after a welding operation has been completed.

Alloy bars are commonly stress-relieved in furnaces. Temperatures under the transformation range are employed, and they are usually in the area from 850 deg to 1200 deg F. The amount of time required in the furnace will vary, being influenced by grade of steel, magnitude of residual stresses caused by prior processing, and mass effect of steel being heated. After the bars have been removed from the furnace, they are allowed to cool in still air to room temperature.

In the case of quenched and tempered alloy bars, the stress-relieving temperature should be about 100 deg F less than the tempering temperature. Should the stress-relieving temperature exceed the tempering temperature, the mechanical properties will be altered.

Items other than bars (parts, for example) can be wholly or selectively stress-relieved. If the furnace method is used, the entire piece is of course subjected to the heat; selective relieving is impossible. However, if a liquid salt bath or induction heating is used, the piece can be given overall relief or selective relief, whichever is desired.

Detailed information about stress-relieving is available at all times through Bethlehem's technical staff. Feel free to consult with our metallurgists, who will cooperate fully without cost or obligation on your part. And remember that Bethlehem can furnish the entire range of AISI standard alloy steels, as well as special-analysis steels and all carbon grades.

If you would like reprints of this series of advertisements from No. I through No. XX, please write to us, addressing your request to Publications Department, Bethlehem Steel Company, Bethlehem, Pa. The first 20 subjects in the series are now available in a handy 36-page booklet, and we shall be glad to send you a free copy.

BETHLEHEM STEEL COMPANY
BETHLEHEM, PA.

On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation. *Export Distributor:* Bethlehem Steel Export Corporation

BETHLEHEM STEEL

(Continued from page 45)

167. Plating Thickness

tive compound which is water

is water soluble

(Continued from page 45)

153. Marking Metal
Bulletin on electromark process. Equipment. Operating instructions. *Electromark Corp.*

154. Melting Furnace
New 4-page bulletin on new 60-cycle coreless induction melting furnaces. Data for melting iron, aluminum, copper alloys. *Ajax Engineering*

155. Metal Cleaning
Data sheet on Alkontrol, addition agent for metal cleaning and cyanide copper baths. *Northwest Chemical Co.*

156. Metal Treatment
Booklet on metal treating and finishing products. *John Swift Chemical Co.*

157. Metallograph
12-page book on desk-type metallograph. *American Optical*

158. Metallographic Equipment
12-page catalog E-29 describes bright-field equipment for visual observation and photography. *Bausch & Lomb*

159. Microhardness Tester
Data on combination microhardness tester and metallurgical microscope. *Sheffield Corp.*

160. Microhardness Tester
Bulletin describes the Kentron microhardness tester. *Torsion Balance Co.*

161. Microscopes
40-page catalog on metallographs, metallurgical, toolmakers, stereoscopic, polarizing, phase and other microscopes. *Unitron Instrument Div., United Scientific*

162. Moisture Analyzer
Data on electrolytic analyzer for control of moisture in gases. *Manufacturers Engineering and Equipment Corp.*

163. Nondestructive Testing
8-page bulletin on equipment for nondestructive testing of bars, rods, tubing. *Magnetic Analysis*

164. Pickling Baskets
Data on baskets for degreasing, pickling, anodizing and plating. *Jelliff*

165. Pickling Baskets
12-page bulletin on mechanical picklers, crates, baskets, chain and accessories. *Youngstown Welding & Eng'g*

166. Plating
New 12-page bulletin on anodes, anode accessories and chemicals for electroplating and finishing. *Hanson-Van Winkle-Munning*

167. Plating Thickness
Metal Digest V-3, No. 2, on sample preparation and optical measurement of plating thicknesses. *Buehler, Ltd.*

168. Powder Metallurgy
Folder on tooling for powder metallurgy discusses high speed steels, die steels. *Vanadium-Alloys Steel Co.*

169. Powder Press
Dorst automatic press for powdered metal is described in bulletin. Pressure ram stroke and other specifications. *Arnhold Ceramics*

170. Powdered Iron
Properties of Plast/Iron with and without copper. *Plastic Metals Div.*

171. Precision Casting
4-page bulletin on Accu-Cast method of casting mold and die components without subsequent machining. *Manco Products*

172. Prevention of Rust
Folder on solvent detergent that cleans and protects. For use in spray washing machine. *Oakite Products, Inc.*

173. Protective Coatings
Folder 301 on industrial protective coatings of rubber, neoprene and other materials. *Arco Steel Fabricators*

174. Quenching
Data sheet 29 on quenching oil includes data on effect of agitation, advantages and specification. *Sun Oil*

175. Radiation Products
8-page catalog on equipment for nuclear research. Radioactive sources, shielding and exposure equipment, instruments, services. *Budd Co.*

176. Radiography
16-page booklet on materials and accessories for industrial radiography. Guide to selection of film. Recommended development techniques. *Eastman Kodak, X-Ray Div.*

177. Recirculating Furnace
Bulletin on continuous-type recirculating furnace shows design of furnace, its operation. *Industrial Heating Equipment*

178. Refractories
24-page bulletin R-35 on castables, insulating concrete mixes, plastics, ramming mixes, and mortars. *Babcock & Wilcox*

179. Refractories
New 24-page pocket-size booklet on selection of castables, cements, ramming mixes and patches. *Chas. Taylor Sons Co.*

180. Rust Preventive
Bulletin on nonflammable rust preventive compound which is water soluble, nontoxic. *Production Specialties*

181. Salt Bath Descaling
12-page bulletin B-40 describes continuous and batch descaling lines for removing oxide from steel, bronze, copper, stainless and titanium. *Drever*

182. Salt Bath Furnaces
Data on salt bath furnaces for batch and conveyorized work. *Upton*

183. Saws
Catalog C-55 describes 35 models of metal-cutting saws. *Armstrong-Blum*

184. Shear
Bulletin on bar and billet shear for rounds, squares, flats, billets and structurals, either hot or cold. *Hill Acme Co.*

185. Shell Molding
4-page reprint on how use of shell cores eliminates machining of large stainless steel castings. *Cooper Alloy Corp.*

186. Shotblasting
16-page "Primer on the Use of Shot and Grit". Problems of blast cleaning operations. *Hickman, Williams*

187. Specification Key
Guide to Government specifications for phosphatizing, rustproofing and paint bonding chemicals. *American Chemical Paint*

188. Spectrometer
8-page Bulletin 44 on direct reading spectrometers. Operation and construction. *Baird Atomic*

189. Spring Steels
Spring steel catalog offers 785 sizes of hardened and tempered spring steels, and 133 cold rolled and bright annealed sizes in stock. *Sandvik Steel*

190. Stainless Fasteners
24-page catalog 56-A lists sizes and types. 7000 items included. *Star Stainless*

191. Stainless Steel
Booklet on 430 stainless. Properties, fabrication. *Sharon Steel*

192. Stainless Steel
24-page booklet on stainless bar and wire. Forms available, grades. Advantages, properties, fabrication, electropolishing, ebonizing. *Armco Steel Corp.*

193. Stainless Steel
32-page book on corrosion resistance of stainless steels. 18 tables on tests in acid, neutral and alkaline solutions. *International Nickel*

194. Stampings
16-page brochure on story of stamping. Handy tabular data. *Republic Steel*

FIRST CLASS
PERMIT No. 1595
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Cleveland, Ohio

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195. Stampings

195. Stampings
6-page folder tells how deep drawn stampings are produced. *Transue & Williams*

196. Steel
256-page handbook lists sizes, weights, lengths, steels available, shapes. Data on mechanical properties, standard steel compositions, hardness numbers conversions. *Ryerson*

197. Steel
Bulletin on Yoloy "S" steel. Properties, welding, chemical analysis, corrosion resistance, strength. *Youngstown Sheet and Tube Co.*

198. Steel 52100
Stock list on 52100 tubing, bars and ring forgings. *Peterson Steels*

199. Steel Tubing
New catalog on seamless and electric-resistance welded steel tubing. Sizes, shapes, compositions. *Ohio Seamless Tube*

200. Sub-Zero Treatment
12-page booklet on industrial chilling equipment for shrinking, testing and treating of metals. *Cincinnati Sub-Zero Products*

201. Temperature Control
Data sheet on controls for holding specimen temperatures for stress-rupture and creep testing. *Leeds & Northrup Co.*

202. Temperature Measuring
8-page catalog 175 on optical, micro-optical, radiation, immersion and surface pyrometers. *Pyrometer Instrument Co.*

203. Temperature Measuring
New bulletin 24-1 on selector switches for temperature measuring circuits. Types, construction and capacities. *Thermo Electric*

204. Tempilstiks
Folder 571 on Tempilstik, pellets and Tempilaq, temperature indicating devices. *Tempil° Corp.*

205. Tester
Bulletin No. 4 on universal tester. Capacities, accessories. *W. C. Dillon & Co.*

206. Testing
Literature on pickle pills for testing strength of pickling solutions. *Ferro Corp.*

207. Testing Machines
12-page catalog on ten testers including hardness, ductility, tensile, compression and transverse strength. *Detroit Testing Machine*

208. Thickness Tester
Data sheets give ranges, principle of operation of nondestructive thickness tester. *Unit Process Assemblies*

209. Titanium Alloy
Data sheet on MST 6Al-4V high temperature titanium alloy. Creep and fatigue properties. *Mallory-Sharon Titanium Corp.*

210. Titanium Wire
Conversion table for titanium wire and rod converts diameter sizes to feet per pound or pounds per foot. *Johnston & Funk Titanium*

211. Tool Steels
Bulletin on tool steels, hot work specialty steels, bar stock, billet, sand casting, drill rod, flat ground stock and tool bits. *Darwin & Milner, Inc.*

212. Tool Steels
4-page data sheet on Oilgraph-EZ, sulphur-bearing oil hardening graphitic tool steel. Heat treatment. *Allegheny Ludlum Steel Corp.*

213. Tool Steels
16-page booklet on steels for forging operations. Basic forging operations, equipment. Heat treatment of steels for hot forging. *Crucible Steel*

214. Tube and Bar
Bulletin 156 on Meehanite and Ni-Resist tube and bar stock. Properties and uses. *Centrifugally Cast Products Div., Shenango Furnace Co.*

215. Tubing
Bulletin on stainless and high-alloy tubing and pipe in nuclear energy developments. *Alloy Tube Div., Carpenter Steel*

216. Tubing
Bulletin 3 on small tubing for industry. Sizes, alloys, tempers, tolerances. *Precision Tube Co.*

217. Tungsten Carbide
Technical data and advantages of tungsten carbide with platinum binder for wear resistant and corrosion resistant applications. *Kennametal, Inc.*

218. Ultrasonic Cleaning
Folder on Sonogen ultrasonic generator for metal cleaning. *Branson*

219. Vacuum Alloys
Folder on vacuum melted cobalt, ferrous and nickel-base alloys. Quality control. *Cannon-Muskegon Corp.*

220. Vacuum Furnace
6-page data sheets on high-vacuum furnace for operation at 3600° F. Specifications and operating characteristics. *Richard D. Brew & Co.*

221. Vacuum Furnaces
Bulletin 557 on vacuum furnaces for temperatures to 2100° F. Dimensions of pit and bell types. *Hevi Duty Electric*

222. Vacuum Metallizing
Bulletin 780 gives uses and advantages of vacuum metallizing, materials and properties of vacuum metallized coatings, the process, equipment. *Stokes*

223. Vacuum Metals
21-page report on vacuum melted metals discusses equipment, properties of metals and their applications. *Ajax Electrothermic Corp.*

224. Vanadium in Steel
189-page book on properties of ferrous alloys containing vanadium and their applications. *Vanadium Corp.*

225. Welding
7-page reprint on properties of weld deposits of nickel-molybdenum-vanadium steel. *International Nickel Co.*

226. Welding
16-page bulletin on welding techniques for seam welding low-carbon and stainless steels. Speeds, use of interrupted and continuous current, welding dissimilar thicknesses. *Taylor-Winfield Corp.*

227. Welding Electrodes
84-page pocket-size booklet describes characteristics, coating, sizes of various electrodes and compares them with standard designations and other electrode brand names. *Harnischfeger*

228. Welding Equipment
Catalog on Cadweld process and arc-welding accessories. *Erico Products*

229. Wire Mesh Belts
130-page manual on conveyor design, belt specifications, metallurgical data. *Cambridge Wire Cloth*

230. Zinc Coating
New booklet on zinc coated steel. *Weirton Steel Co.*

231. Zirconium
New 8-page booklet on properties and applications of commercial grade zirconium. Chart compares corrosion resistance with tantalum, Hastelloy C and type 316 stainless. *Columbia-National Corp.*

232. Zirconium
8-page brochure on zirconium's corrosion resistant properties. Applications based on this property. *Carborundum Metals Co.*

233. Zirconium
New 18-page pocket-sized book on manufacture, properties, metallography, machining, metal powders. Extensive bibliography. *Titanium Alloy Mfg. Div.*

January, 1958

1	21	41	61	81	101	121	141	161	181	201	221
2	22	42	62	82	102	122	142	162	182	202	222
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5	25	45	65	85	105	125	145	165	185	205	225
6	26	46	66	86	106	126	146	166	186	206	226
7	27	47	67	87	107	127	147	167	187	207	227
8	28	48	68	88	108	128	148	168	188	208	228
9	29	49	69	89	109	129	149	169	189	209	229
10	30	50	70	90	110	130	150	170	190	210	230
11	31	51	71	91	111	131	151	171	191	211	231
12	32	52	72	92	112	132	152	172	192	212	232
13	33	53	73	93	113	133	153	173	193	213	233
14	34	54	74	94	114	134	154	174	194	214	
15	35	55	75	95	115	135	155	175	195	215	
16	36	56	76	96	116	136	156	176	196	216	
17	37	57	77	97	117	137	157	177	197	217	
18	38	58	78	98	118	138	158	178	198	218	
19	39	59	79	99	119	139	159	179	199	219	
20	40	60	80	100	120	140	160	180	200	220	

METAL PROGRESS,

7301 Euclid Avenue, Cleveland 3, Ohio

Please have literature circled at the left sent to me.

Name ______________________

Title ______________________

Company ______________________

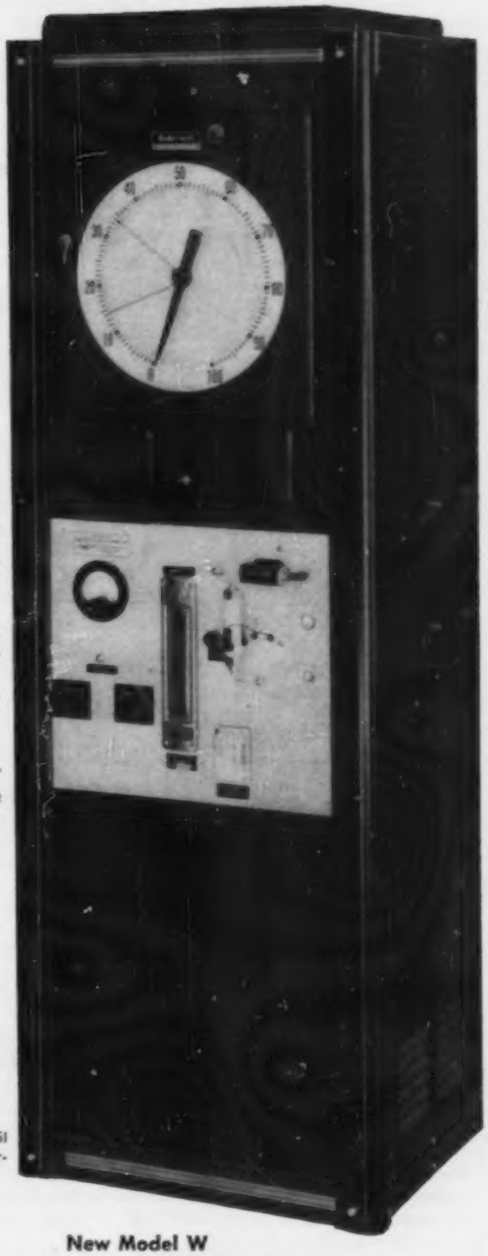
Address ______________________

City and State ______________________

Postcard must be mailed prior to April 1, 1958.
Students should write direct to manufacturers.

Measures, records, controls moisture content of furnace gases—

automatically!

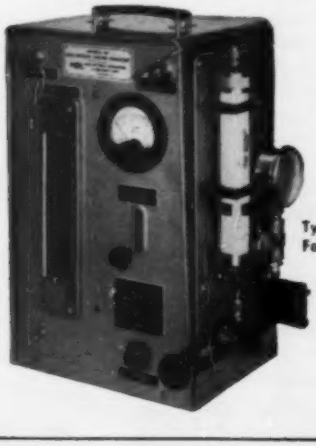


- This single instrument controls and measures furnace atmospheres over dew points ranging from below −100°F to greater than +100°F.
- Enables you to hold moisture content of furnace gases within narrow limits — anywhere from one part per million to one hundred thousand parts per million!

With this revolutionary new instrument you need never worry about the moisture content of furnace gases being too high, or too low.

That's because the new *Meeco* Model W Electrolytic Moisture Analyzer enables you to hold the moisture content of furnace gases to optimum values . . . *automatically* . . . within your exact specifications.

Why not let our engineers furnish recommendations concerning the Model W for your own particular process? Write for complete information today!



Type NEP-PL
For measurement only
(Shown with Model A Oil Separator and Model I Vaporizing Valve, optional)

New Model W
Electrolytic Moisture Analyzer

MEECO *Instruments*

MANUFACTURERS ENGINEERING & EQUIPMENT CORP. Hatboro • Pa.

A Review of the Phosphate Coatings

Specified for the Protection of Metal Surfaces

By HUGH GEHMAN, Assistant Manager, Product Development Dept., AMERICAN CHEMICAL PAINT COMPANY

Phosphate coatings are protective inorganic finishes that actually change the chemical nature of metal surfaces. The metal reacts with the applied phosphate solution to form a nonmetallic, crystalline coating which serves to:

- **Improve paint adhesion**
- **Provide protection against corrosion**
- **Increase lubricity of friction surfaces**
- **Facilitate mechanical deformation of metals**
- **Decorate—in many instances**

Satisfactory protection of steel, zinc and aluminum surfaces against corrosion, paint peeling and blistering, and hard wear requires precision methods of chemical conversion coating.

Types of Conversion Coatings

There are seven classes of chemical conversion coatings commonly specified and used throughout industry today. They are as follows:

Zinc-iron phosphate (ACP Granodine®). This is the heaviest type of coating (gray in color) used for prepaint treatments on steel, iron and zinc surfaces. The process requires five or six operations: cleaning; rinsing; rust removal, if necessary; coating; rinsing; and a second rinse. Coating weight ranges from 100 to 600 mg per sq. ft.

Medium or large volume production of automobile bodies, appliances, projectiles and cabinets can be handled effectively.

The coating solution improves paint adhesion by forming a crystalline deposit over the metal surface. This deposit is rough, as revealed microscopically, and so offers an ideal gripping surface for paint particles.

Manganese-iron phosphate (ACP Thermoil-Granodine®). This is a heavy black coating used on friction surfaces to prevent galling, scoring and seizing of parts. Typical metal parts treated are pistons, piston rings, gears, cylinder liners, camshafts, tappets and various small arms components.

Iron phosphate (ACP Duridine®). This is a comparatively new process that places a light coating on surfaces for improved paint adhesion. Since cleaning and coating occur in the same bath, it has only three to five stages.

The iron phosphate treatment is a spray process suited for medium to large volume, large or small work. Precleaning is normally unnecessary, an economy factor in its favor.

Products protected by this process are steel or iron fabricated units, such as cabinets, washing machines and refrigerators. Weight of coating is 50 to 100 mg per sq. ft.

Zinc phosphate (ACP Lithoform®). This is a crystalline coating produced on galvanized iron and other zinc surfaces—also cadmium—for improving paint adhesion. The purpose of the coating is to provide a paint-gripping surface and to prevent the reaction between acidic components of the paint and the zinc metal, with the formation of soaps and loss of paint adhesion.

This coating is applied in weights of 75 to 500 mg per sq. ft. There are no limitations on volume or production or on size of products treated. Zinc phosphate coating is used on zinc alloy die castings, zinc or cadmium plated sheet or components, hot dip galvanized stock, and Galvanneal.

Amorphous phosphate (ACP Alodine®). This is a relatively new protective coating for aluminum and aluminum alloys. It may be used in place of anodic deposition for improved paint adhesion and corrosion resistance.

This coating is practical for production in any volume. Coating weight is 100 to 600 mg per sq. ft. Products treated include helmets, belt buckles, aircraft and aircraft parts, bazookas and rocket motors, roofing and siding. Particularly good when aluminum is painted prior to forming.

Zinc-iron phosphate for oil absorption (ACP Permadine®). This is a relatively heavy coating adapted to the retention of rust-inhibiting drying or nondrying oils and waxes on ferrous metal surfaces. The coating is applied to a weight of 1000 to 4000 mg per sq. ft.

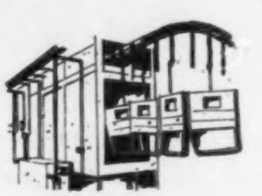
The process is satisfactory for large or small work in any volume—nuts, bolts, hardware, guns, tools, etc.

Zinc-iron phosphate for metal forming (ACP Granodraw®). This is a specialized coating used in conjunction with a suitable lubricant to facilitate the cold mechanical deformation of steel. The coating acts as an anchor for the lubricant throughout drawing, extrusion, and cold forming operations.

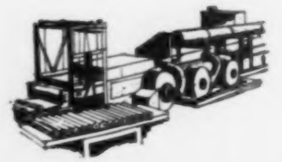
It is a successful treatment for products such as blanks and shells for cold forming, heavy stampings, impact extruded shapes, drawn wire and tube.

For more complete information about any one or all of these chemical conversion coatings, contact an ACP sales representative or write us at Ambler, Pa.

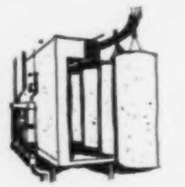
Typical Installations of Phosphate Coating Systems



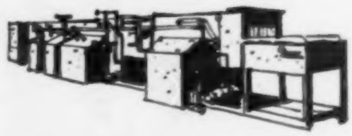
Customer: Truck manufacturer
Problem: Preparing cab parts for painting
Cycle: Phosphate wash; phosphate wash; rinse; chromic acid rinse; dry



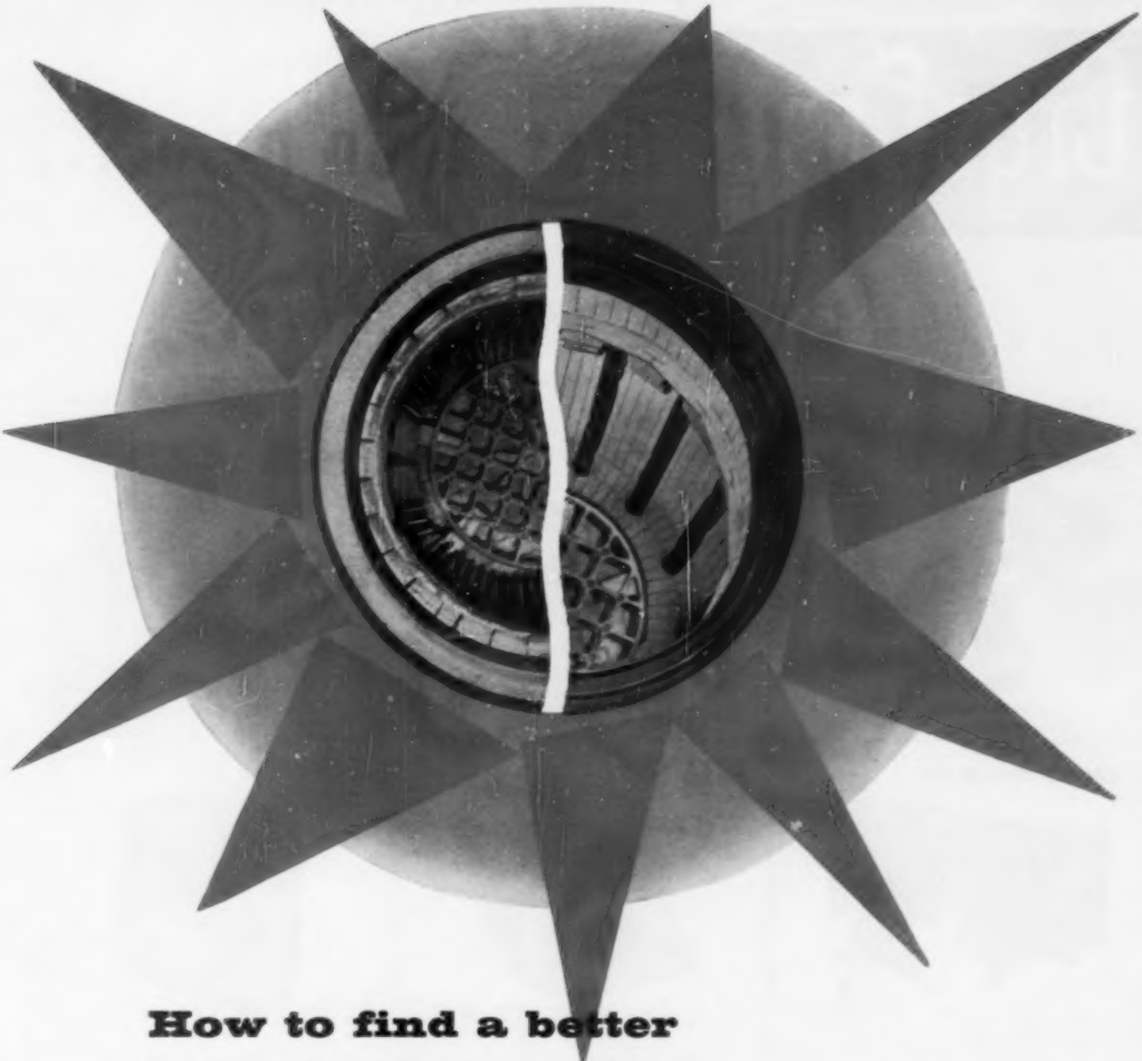
Customer: Aluminum screen manufacturer
Problem: Final finish of aluminum shade screen
Cycle: Wash; rinse; phosphate coat; rinse; chromic acid rinse; dry

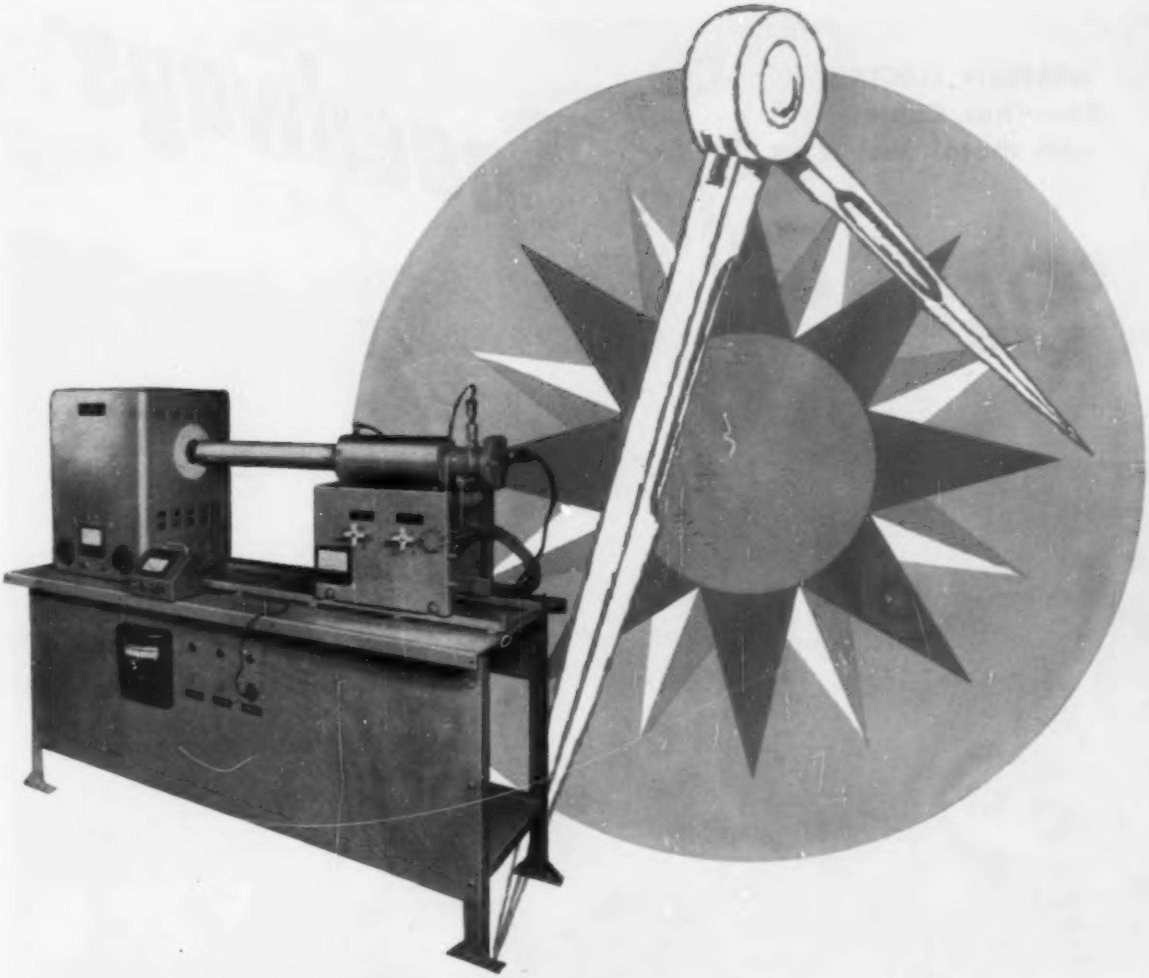


Customer: Water heater manufacturer
Problem: Preparation of water heater shells for synthetic enameling
Cycle: Phosphate wash; rinse; chromic acid rinse; dry



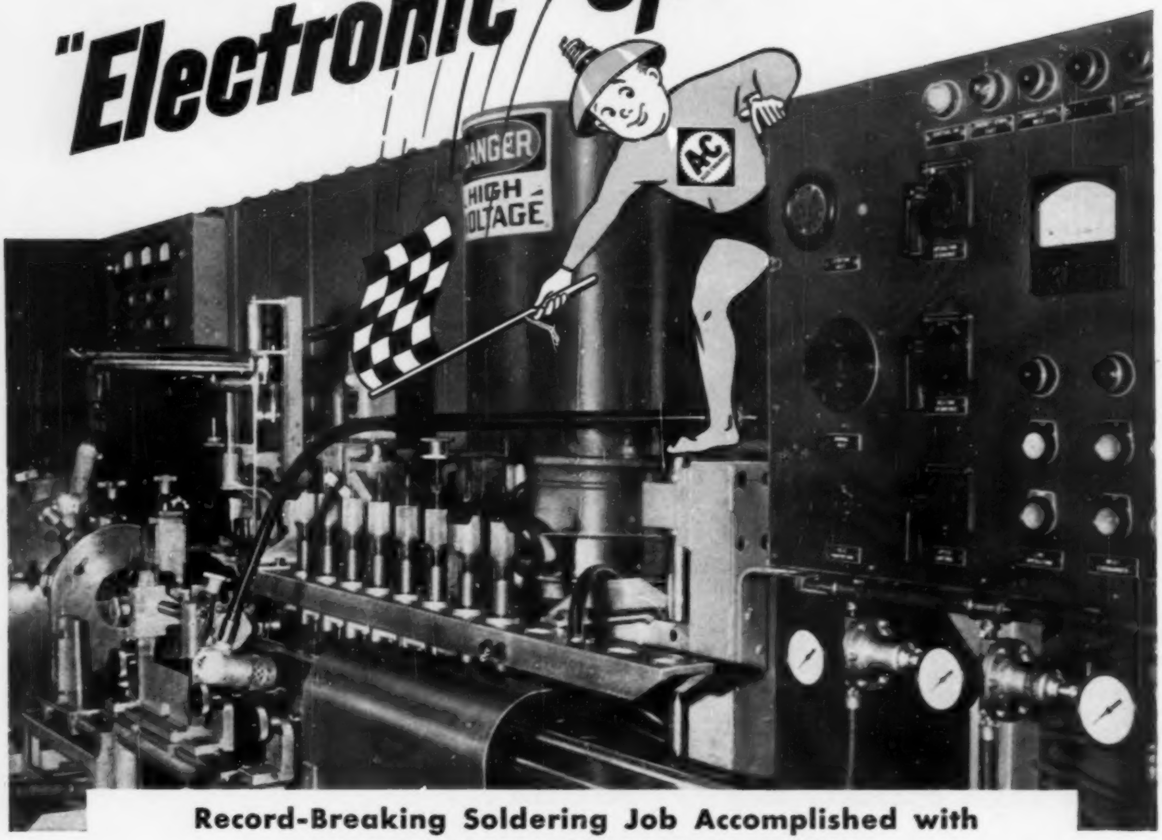
Customer: Hardware manufacturer
Problem: Preparing hardware parts for painting
Cycle: Wash; rinse; phosphate coat; rinse; chromic acid rinse; dry





WESTERN ELECTRIC
Sheathes Cable
with Metal Jacket on

"Electronic Speedways"



Record-Breaking Soldering Job Accomplished with ALLIS-CHALMERS INDUCTION HEATERS

BEHIND your taken-for-granted telephone is busy *Western Electric* — manufacturing and supplying units of the Bell System. The Allis-Chalmers induction heater is typical of the scientifically engineered machinery utilized by Western Electric in turning out record-breaking quantities of equipment and apparatus essential to dependable service.

In Western Electric's ultra-modern cable sheathing operation, four Allis-Chalmers 50-kw induction heaters at Kearney, N. J., and four identical units at Chicago make up electronic speedways.

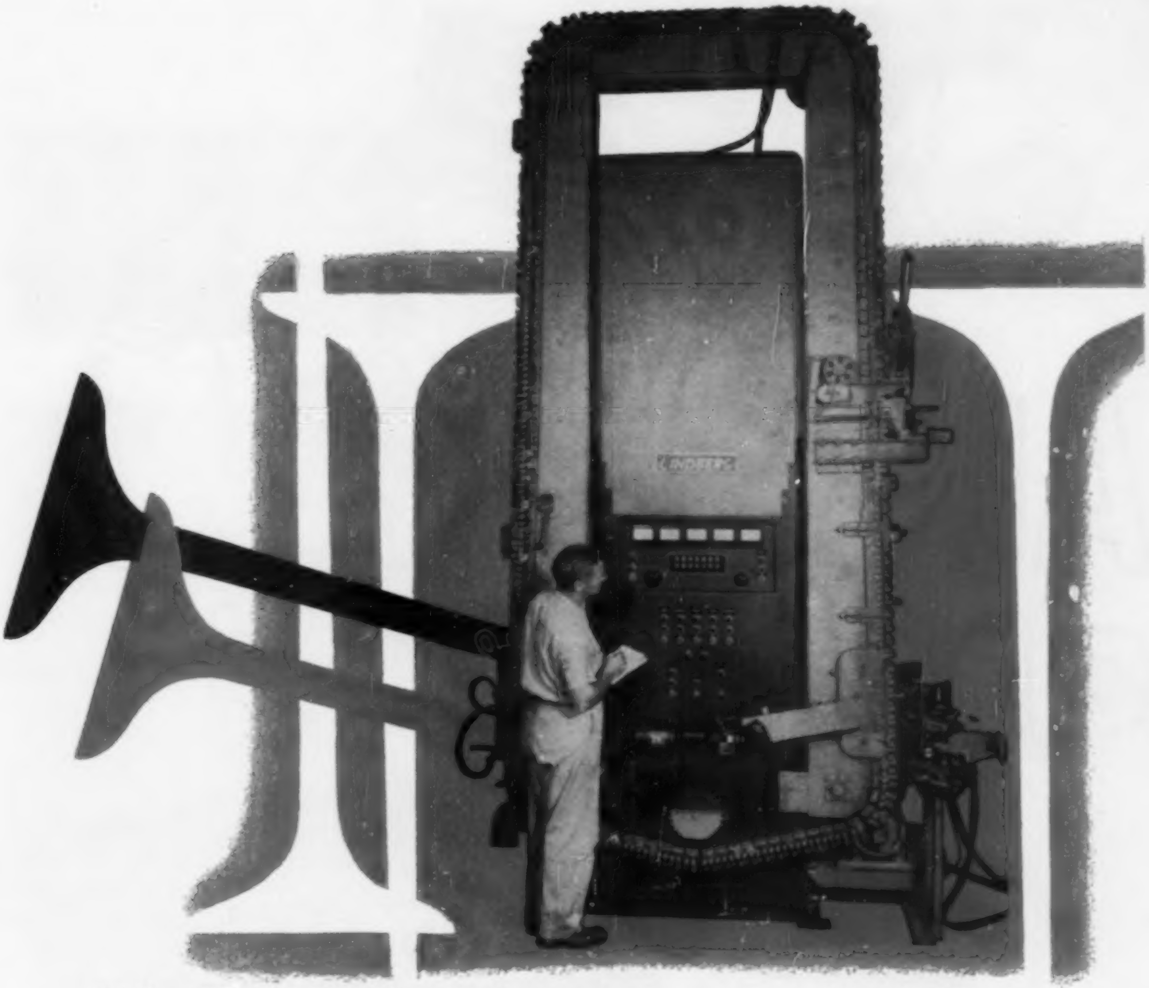
Telephone cables 1¼-inch through 3-inch outside diameter race beneath specially designed induction coils which induce heat into the overlapping areas of the corrugated metal sheathing enclosing the cables. Amount of heat induced depends upon cable speed. Voltage-generating tachometers, magnetic amplifiers and saturable reactors control amount of heat supplied by the coils. Heat is accurately controlled through all speed ranges.

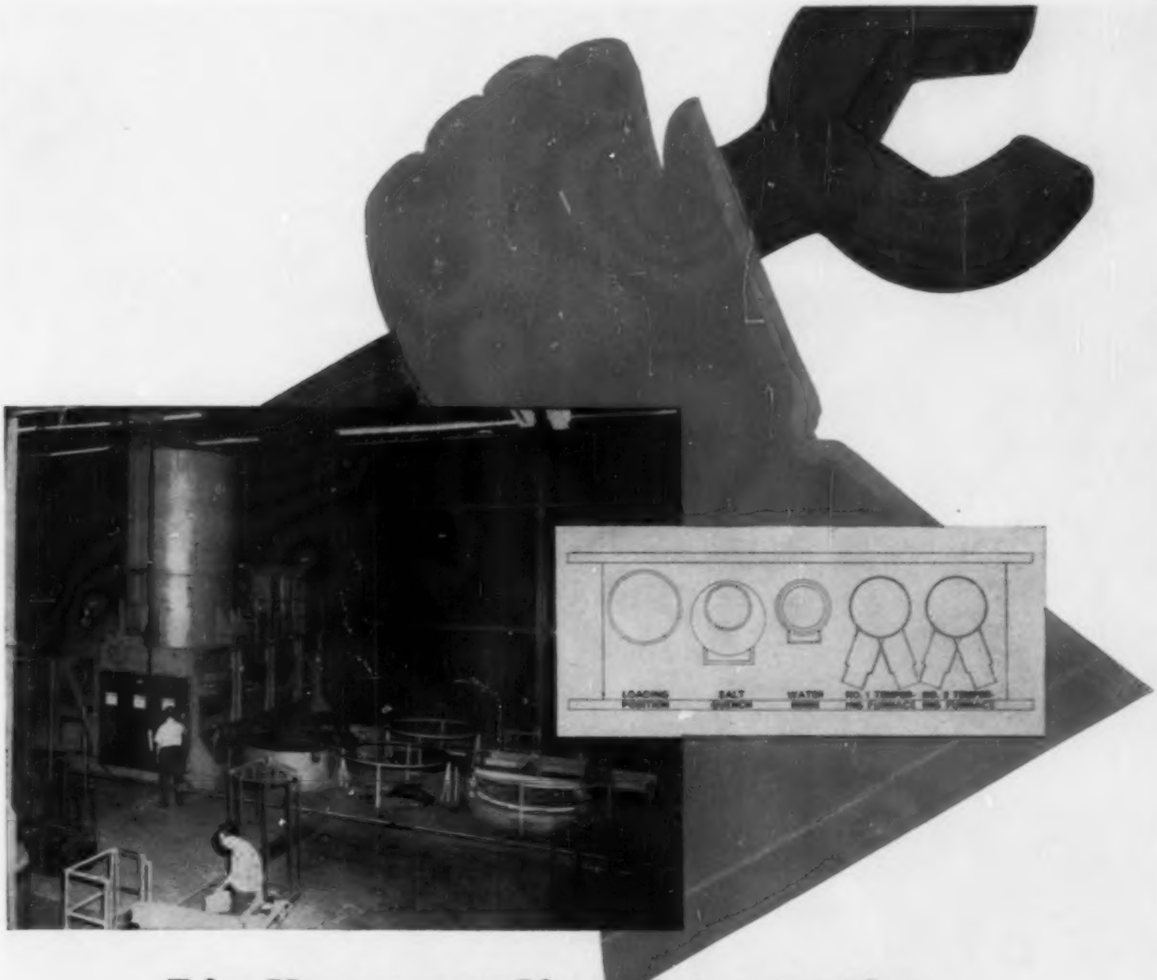
Mr. Hi Frequency is ready and able to help you, too

If your job is one of brazing, soldering, hardening, annealing, or melting, it will pay you to get all the facts on induction heating. Contact your A-C representative or write Allis-Chalmers, Industrial Equipment Division, Milwaukee 1, Wis.

ALLIS-CHALMERS

A-5373

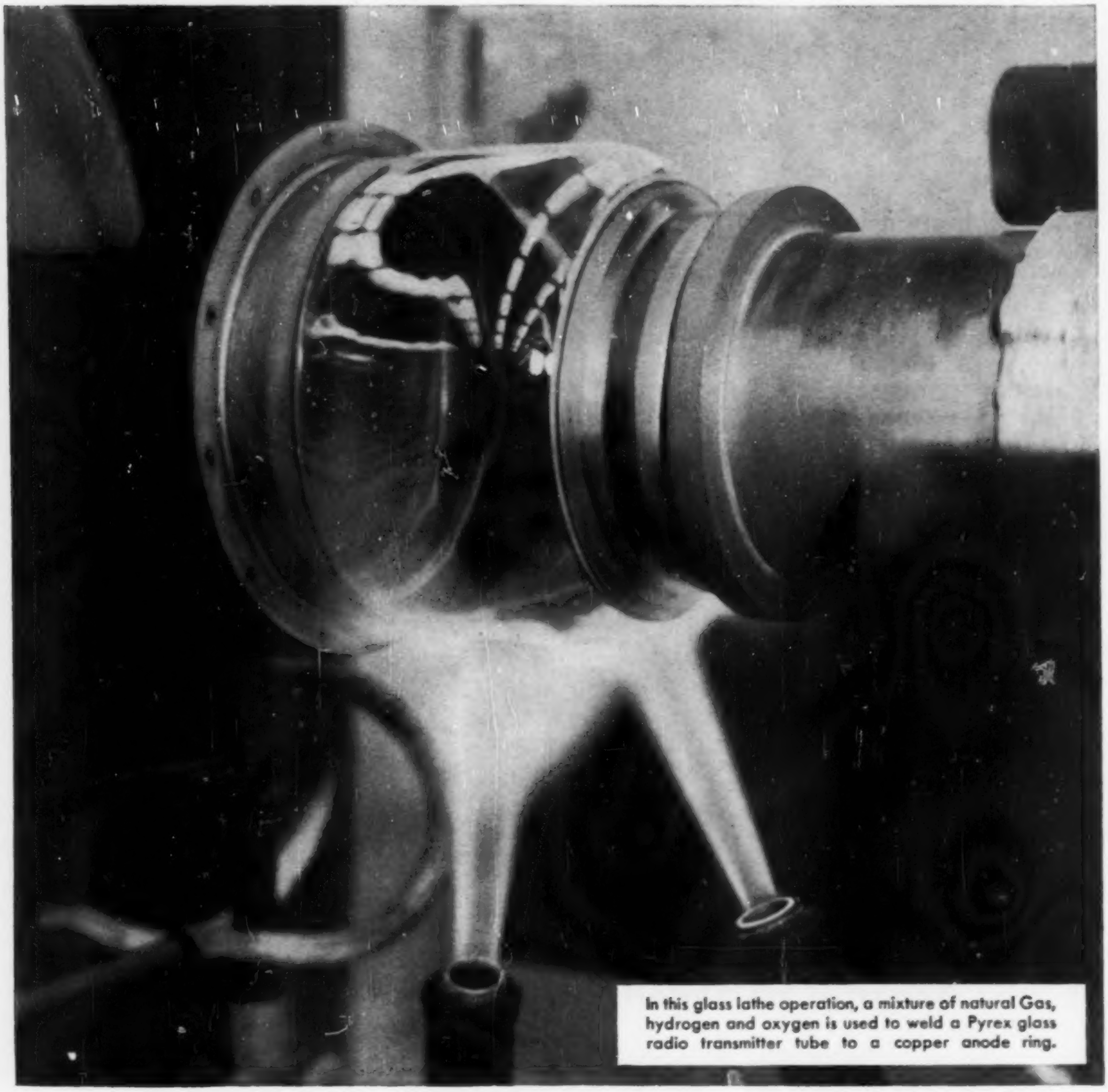




Lindberg applies the creative touch to field-installation

Here is an example of Lindberg's creative touch in field-installed heat treating equipment. Our unique design of this movable overhead furnace saved space, labor and time and increased quality and operating efficiency in missile manufacturing. We have the technical staff and the experienced engineers to design and install for you any requirement you may have for the application of heat to industry. Our service covers all types of heat treating furnaces, aluminum melting and holding furnaces, high frequency units, ceramic kilns, controls and all facilities required to fit this equipment into your production processes. We specialize in "turn-key" operations covering everything from design and engineering to the finished job installed in your own plant. Whatever your industrial heating problem, a good way to solve it is to talk it over with Lindberg. Just get in touch with your local Lindberg Field Representative (See classified phone book) or write Lindberg Industrial Corporation, 2448 West Hubbard St., Chicago 12, Illinois. Los Angeles Plant: 11937 S. Regentview Avenue, at Downey, California.

LINDBERG heat for industry



In this glass lathe operation, a mixture of natural Gas, hydrogen and oxygen is used to weld a Pyrex glass radio transmitter tube to a copper anode ring.

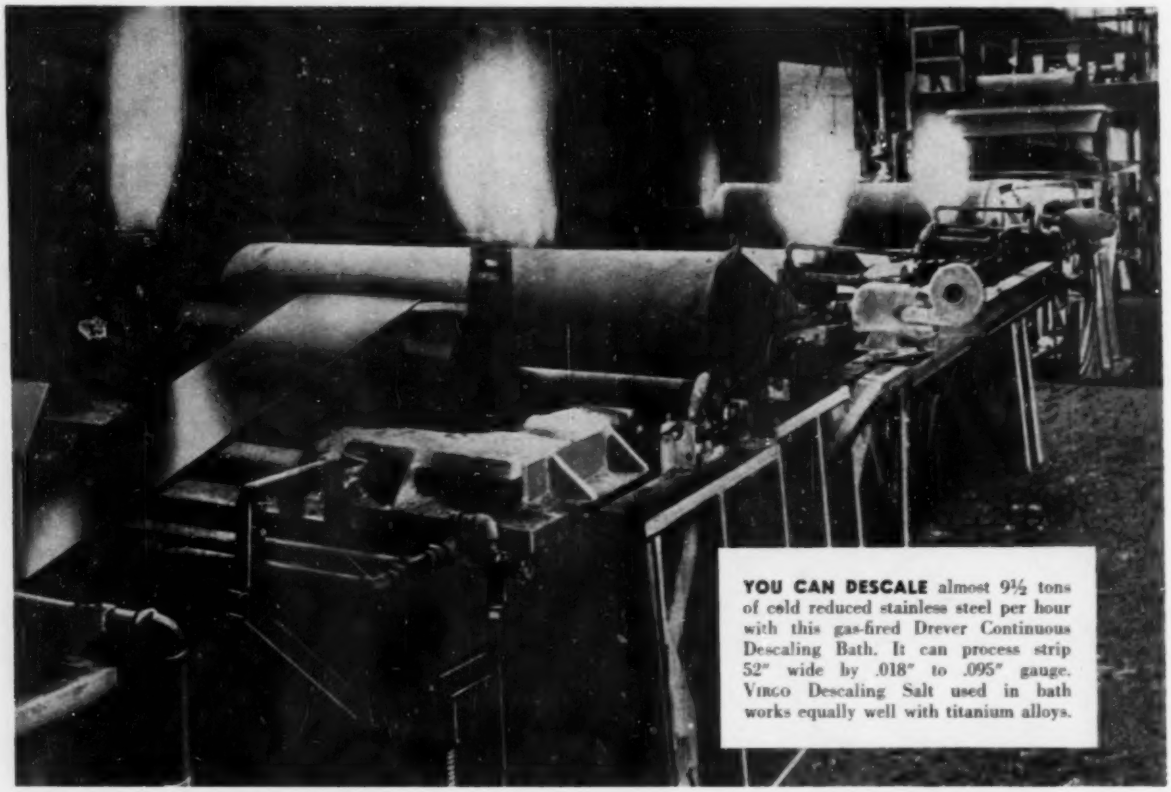
RCA welds glass to metal at over 2000° F. ...thanks to GAS

Natural Gas is used to weld glass to metal in the production of radio and television tubes of many types at the RCA Tube Division plant in Lancaster, Pennsylvania.

To effect the weld at over 2000° F., a mixture of natural Gas, hydrogen and oxygen maintains the high welding temperature on the Pyrex glass and metal parts as they rotate on a glass lathe. A Gas flame is then used to control and equalize the cooling of the glass down to the 900-600° F. range.

For information on how Gas can help you in your production operations, call your Gas Company's industrial specialist. He'll be glad to discuss the economies and superior results you get with Gas and modern Gas-fired industrial equipment. *American Gas Association.*

See Playhouse 90 with Julia Meade on CBS-TV. Watch local listings for time and station. Sponsored by your Gas Company and the Gas Industry.



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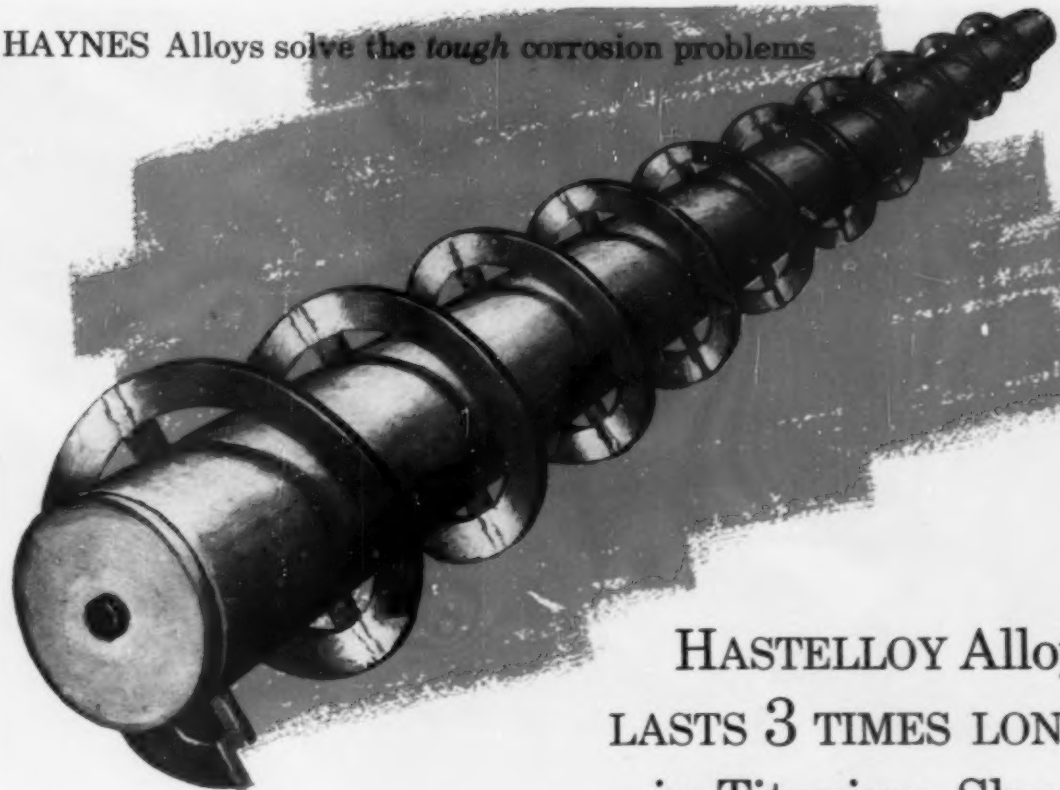

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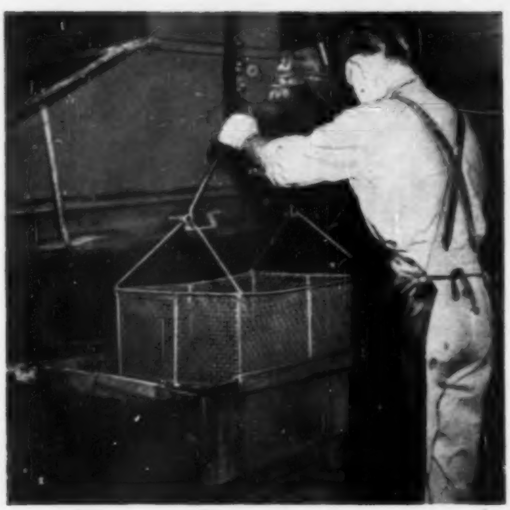

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Metal Progress
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Oxygen Rejuvenates the Converter Process

*By E. C. WRIGHT**

The Linz-Donawitz (L-D) process of blowing impurities out of pig iron with a stream of pure oxygen striking the top of the bath is now operating in Hamilton (Ont.) and Detroit. The prediction is made that its use will expand rapidly in America where new steel capacity is needed. (D10a; ST)

THE USE of pure oxygen instead of air for refining molten pig iron is as old as the bessemer process itself. In fact, Bessemer suggested the use of oxygen nearly 100 years ago. At that time no one knew how to produce it on any large scale and the idea was dormant for over 80 years. Finally in 1937, C. V. Schwartz in Germany demonstrated the advantage of blowing blast furnace iron with oxygen instead of air and received patents on his work. The cost of oxygen at that time was still too high and, in addition, the detrimental effects of nitrogen on the welding, cold forming, and aging of air-blown steel were just beginning to be recognized.

The steelmaking situation in Europe is radically different from that in America; production methods are determined by the quality of raw materials, fuels, and markets in the two regions. Scrap is scarce in Europe because much of the steel made is exported; in the United States scrap has usually been plentiful. All fuels are cheaper in the United States than in Europe. As a result of these two main factors, 90% of American steel has been made in basic openhearth furnaces for over 50 years. On the other hand, over 60% of European steel has been made by the basic lined, bottom air-blown converter process from the high-phosphorus pig irons produced in blast furnaces in England, Germany, France and Belgium. This old process (Thomas-Gilchrist) yields a type of steel which is high in nitrogen (usually over 0.015%) and such steel was steadily becoming inadequate for meeting increasingly

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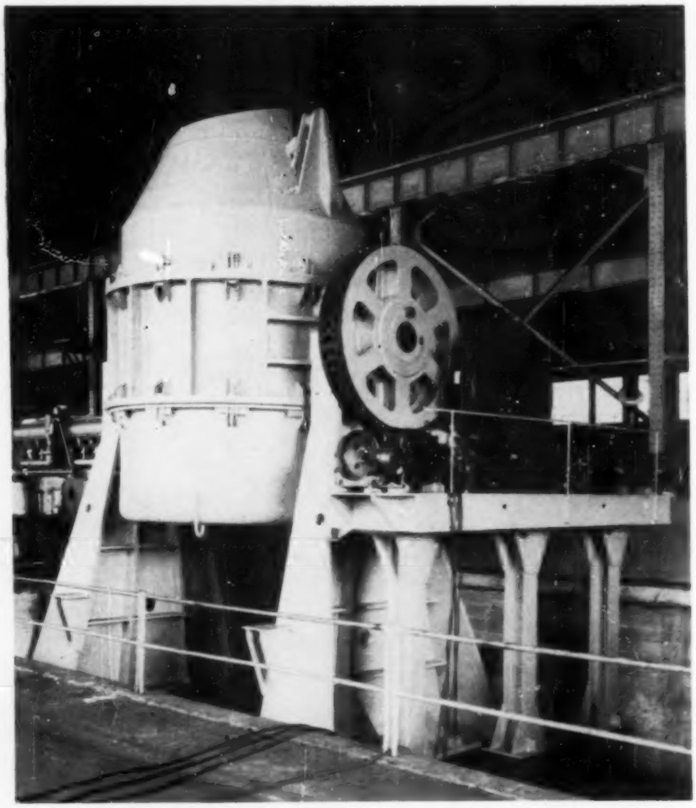


Fig. 1 – First American Vessel During Final Stages of Construction. Courtesy Pennsylvania Engineering Corp.

rigid specifications. European steel producers were faced with the dilemma of changing over half their producing capacity to openhearth or electric furnace plants, or to do something about the very troublesome nitrogen in the steel. New steelmaking plants would have cost enormous sums and raised the price of steel in Europe.

Most steel made in stationary openhearths contains less than 0.005% nitrogen, while bottom blown converter steel will have between 0.012 and 0.018%. A difference of only 0.010% nitrogen thus determines the process by which steel must be made! Over 80% of all steel is of low carbon content (under 0.20%) for such products as sheet, strip, plate, skelp, wire, pipe and structural shapes, and small amounts of nitrogen have become increasingly troublesome to fabricators. These steel products are mostly made of rimming or semi-killed steels and the low-nitrogen openhearth steels are now usually specified. As a result the old acid bessemer process almost became obsolete in America where it is still used for only a few special grades of steel. As remarked above, the bottom blown basic converter steel became more and more undesirable in Europe because of its high nitrogen content.

After World War II intensive study of this nitrogen problem got under way in Europe. It had long been known that the steel bath in the converter remained low in nitrogen as long as the carbon content was above 0.50%. German metallurgists found that if the air blast was stopped at some such carbon level, additions of roll scale or ore would supply sufficient oxygen to reduce the carbon to the desired content without adding any nitrogen, and a considerable tonnage of low-nitrogen Thomas converter steel was made in this manner. However, these large ore additions are likely to chill the bath below the proper pouring temperature. The slag volume also increased and the final analysis of the melt was difficult to control.

Other steel men in Sweden, Belgium, France and Germany were also busily investigating the use of pure oxygen for finishing the blow in spite of its cost. It was soon found that if the air blast was stopped at a certain carbon level, pure oxygen could then complete the purification without increasing the nitrogen content above about 0.004%. This resulted in a blowing

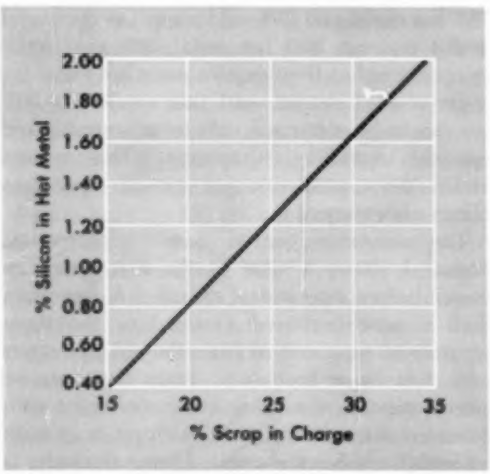
cycle such as 8 to 10 min. with air followed by 2 to 3 min. with pure oxygen.

Such bottom blowing with oxygen generated very high temperatures and also reduced bottom life due to excessive tuyere erosion. Temperature control was soon established by additions of cold scrap or iron ore before the final oxygen blow or by mixing steam or CO_2 gas with the oxygen in the final stages.

All four methods have been used in Europe during the past ten years and are making good quality basic steel with low nitrogen contents (under 0.004%). Thus, by the use of a relatively small amount of oxygen for the final blowing stages, steel of a quality equal to basic openhearth is being produced in large quantities, and the old Thomas basic converter process was saved from gradual extinction. As a result, several new converter plants, totalling about 65 vessels using oxygen after blowing, have been erected.

Pierre Coheur first described the operation of oxygen-steam blowing in Belgium at the A.S.M.'s First World Metallurgical Conference (see *Metal Progress*, Oct. 1951, p. 79). Since that time most steel in Belgium and Luxembourg has been made in this way. It seems to be the most easily controlled method as to final temperature and composition. In Sweden the basic bessemer steel capacity has been doubled and now exceeds 800,000 tons per year; the Swedes are using oxygen plus CO_2 or oxygen and ore additions for final blowing stages. French papers on this subject have mostly discussed the final blow with pure oxygen associated with scale or scrap additions. All have dealt with the purification of high-phosphorus hot metal (1.50 to 2.00% P) which is produced in most of the West European blast furnaces.

Fig. 2 – Relation of Silicon in Hot Metal and Amount of Scrap Necessary to Keep Temperature Within Bounds. From D. O. Davis, "The Oxygen Steelmaking Process", Iron and Steel Engineer, Oct. 1955, p. 90



At the same time many investigators continued their trials of pure oxygen for blowing molten pig iron. This work was stimulated by the development of the Linde-Frankl process for the production of tonnage oxygen at a reasonable cost (under $10 per ton). Since bottom blowing with oxygen for the whole cycle was undesirable, due to the short bottom life, the oxygen was blown through a vertical pipe ending just above the bath; the oxygen was at high pressures (100 to 150 psi.) to blow the slag aside and penetrate the metal beneath. A water cooled copper casting distributed the oxygen jet and this was attached to a long, water cooled pipe which could be raised or moved aside when the converter is tilted for charging or discharging. Work at Maxhutte Works and Duisberg in Germany and at Linz and Donawitz in Austria with 2-ton pots demonstrated the many advantages of blowing entirely with pure oxygen. This was promptly recognized in Austria, since the iron produced from Styrian ores contains less than 0.20% phosphorus and could not be processed in the bottom air-blown basic converters (which require at least 1.50% P for the after-blow).

Top blowing with oxygen indicated several important features entirely different from bottom blowing with air:

1. Very high temperatures were generated which had to be controlled with additions of cold scrap or ore.
2. Large additions of cold scrap (20 to 35% of the charge) could be melted (instead of about 8% in bottom air-blown converters).
3. Phosphorus is burned out simultaneously with carbon (contrary to air-blown operations).
4. Sulphur is reduced by one third to one half.
5. Oxygen efficiency is 90 to 95%.
6. Refractory consumption is much less than in bottom blown converters and in openhearth furnaces.
7. Bath temperature is directly proportional to the silicon content of the hot metal.
8. Steels containing less than 0.004% nitrogen are made with 99.5% oxygen blast.

After three years of development work in Austria plants were built at both Linz and Donawitz in 1953 to use the top blown oxygen process – now called the Linz-Donawitz Process (L-D

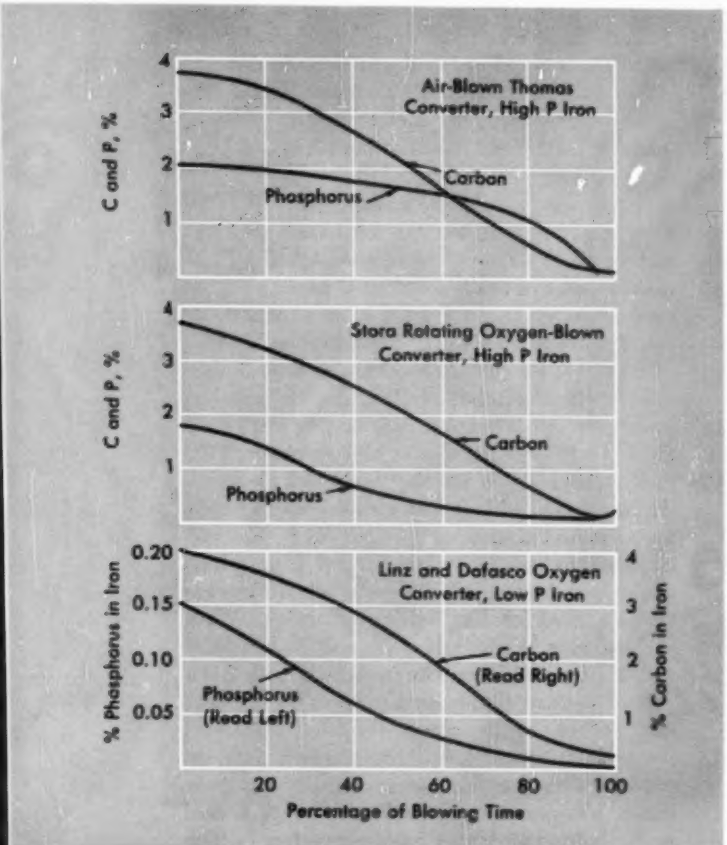


Fig. 3 – Rates at Which Carbon and Phosphorus Are Removed in the Various Irons and Converters

for short). These two plants have between them five 35-ton converters with a total capacity of 250,000 tons per year. They were an immediate success and demonstrated that quality steel could be readily made equal to any openhearth product. During the past four years metallurgists from all over the world have made pilgrimages to Austria to observe the operations of these novel and highly successful plants. Most of these visitors were so impressed that many new installations of oxygen blown converters are now in the planning stage; at least 15 plants employing the L-D process are now under construction in eight different countries.

It may seem curious that, aside from Austria, the oxygen converter process has made little headway in Europe, although in the United States and Canada it is expanding rapidly. This is explained below; it depends on the fact that in these three countries low-phosphorus pig iron is available. In Western Europe the high-phosphorus irons are best handled in conventional basic converters, blown with air enriched in oxygen and finished with oxygen diluted with steam or carbon dioxide.

American Plants

The first oxygen converter plant in North America was erected at the Dominion Foundries and Steel, Ltd. (Dofasco) at Hamilton, Ontario. As described by F. J. McMulkin in *Transactions* of the Canadian Institute of Mining and Metallurgy, 1954, p. 225, this plant has two 45-ton converters. The installation at Detroit (McLouth Steel Co.) has been so satisfactory for making autobody sheet that two new 80-ton ones are now being added, plus a new blast furnace and ore sintering plant. Two other large steel companies have converting departments in the construction stage, building three 65-ton vessels each, and at least four other American steel companies are negotiating engineering contracts for similar installations.

The steel producing capacity of these projects is close to 10,000,000 tons annually. Two 40-ton vessels operating alternately on 30 to 40-min. blowing cycles will produce over 100 tons of steel per hour; two 80-ton vessels operating on similar cycles will produce up to 200 tons of steel per hour. This is four to eight times the production rate of a modern 250-ton openhearth furnace melting a 50% hot metal charge without oxygen lancing. The capital cost of the oxygen converter plants is only about half the cost of an openhearth plant of similar capacity. Since these oxygen converters use a charge of 75% hot metal and 25% cold scrap (as compared to the common 50% hot metal, 50% cold scrap in openhearths) they require more hot metal for a given steel output, and this involves a 50% increase in blast furnace, coke oven, sintering and materials handling equipment. This feature makes the capital cost per ton of equivalent plants about equal.

The converters are of simple construction. Figure 1 shows a view of the first American vessel before operations started. A one-piece shell is now preferred (instead of the three separate sections copied from the old converters with detachable bottoms). Since there are no bottom tuyeres, the lining is rammed solid with dolomite or magnesite mixed with pitch, or built up with basic brick shapes. Lining thickness is

Table I – Average Conditions in Austrian and Canadian Plants Using L-D Process

	Linz	Donawitz	Dofasco
Av. hot metal			
Carbon	4.00%	4.00%	4.40%
Manganese	1.90	2.50	1.30
Phosphorus	0.15	0.08	0.14
Sulphur	0.04	0.05	0.03
Silicon	0.90	0.20	1.10
Av. blown metal			
Carbon	0.04%	0.05%	0.03%
Manganese	0.33	0.35	0.28
Phosphorus	0.025	0.026	0.013
Sulphur	0.024	0.022	0.020
Av. slag			
FeO	14.00%	14.00%	17.00%
Fe_2O_3	7.00	4.00	4.00
SiO_2	15.00	15.00	17.00
CaO	40.00	38.00	45.00
MgO	4.00	6.00	4.00
MnO	14.00	15.00	8.00
P_2O_5	2.50	1.00	1.50
Al_2O_3	2.70	4.70	4.00

18 to 24 in. and may erode to 12 to 18 in. before it is replaced. Only 20 to 30 lb. of refractory are used per ton of steel at Linz and Dofasco. The life of the lining is between 200 and 250 blows – thus an operating vessel must be relined about once a week. The mouth of these converters is much smaller than the waist to prevent air swirling downward into the vessel during the blow.

Operation of these top-blown vessels is much different from the bessemer. It is charged with about 25% cold scrap followed by about 75% hot metal and sufficient burned line or dolomite to make the proper slag. The flux is added in stages – a representative program would be 2, 6 and 20 min. after the start of the blow. After charging, the fume hood is lowered and the oxygen pipe also lowered into the vessel with the oxygen blast on. A quiet flame immediately appears; there is no shower of sparks or long flame as from the bessemer. This very hot flame (about 3000° F.) ascends into the fume hood and aspirates about five times the theoretical amount of air to burn the CO gas. A ring of water sprays around the periphery of the hood also helps cool the hot gases to about 1600° F. in the refractory lined hood, from which they go into large spark chambers and are further cooled with other water sprays to below 500° F. before entering the cleaners.

It is interesting to watch the operations closely, and one can get quite near. The flame steadily brightens as temperature increases. The chimney effect sucks in a large amount of cold air and the action of large fans (150,000 cu. ft. per min.) behind the gas cleaning equipment accentuates this effect. As a result very little fume escapes into the building and the operation is much cleaner than in an old bessemer plant. The gases escaping the mouth of the vessel contain over 90% CO with very little nitrogen. Near the end of the blow the brightness of the flame diminishes and the time to stop the blow is estimated from the chemical analysis of the hot metal charged. When the operator decides the end point is reached the oxygen lance is raised and the vessel turned 90° to horizontal. An immersion pyrometer checks the teeming temperature and a sample is taken for carbon estimation. If temperature is too high, a measured addition of cold scrap is made; if too low, the blowing is continued for a short time.

When the temperature and composition are adjusted the vessel is turned 90° in the opposite direction for pouring into the teeming ladle. An open tap hole on the pouring side of the vessel is located about 18 in. below the converter mouth, which allows the steel to be poured from under the slag; ladle additions of deoxidizers are made to the molten metal.

The silicon content of the hot metal regulates the temperature of the bath and the amount of steel scrap or iron ore to be added. Figure 2 shows this relationship. Both Dofasco and McLouth are charging hot metal with about 1.25% Si and using 25% scrap. (High-grade iron ore pellets are also being considered for this purpose.) The phosphorus content of hot metal at these plants is under 0.20%, and about 125 lb. of lime or dolomite are needed per ton of steel to produce a slag with over 45% CaO to hold the phosphorus. Table I shows the composition of hot metal, blown metal, and slag in operations at the Austrian and Canadian plants. The slag volume is close to 200 lb. per ton of steel and the ratio of (CaO+MgO) to SiO_2 is usually about 3.0. The amount of oxygen blown per ton of steel varies from 1800 to 2000 cu. ft. or about 160 lb. Figure 3 shows how the impurities are removed during the blow.

At present the only operating oxygen plants are converting hot metal with less than 0.25% phosphorus. The question arises as to whether the process will make steel with a larger amount of phosphorus – such as the 0.90% Alabama iron and 1.5% Benelux irons now using the Thomas bottom blown vessels. Springorum, Speith, and Oelsen described in *Stahl und Eisen*

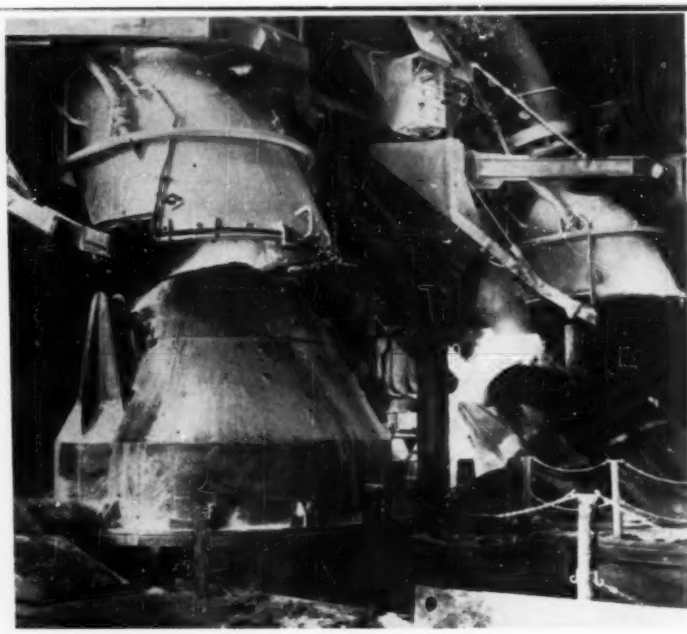


Fig. 4 – Two Oxygen Converters in Operation at McLouth Plant – at Left in Blow, at Right Tilted for Charging. Casting pit in right foreground

for Jan. 1, 1953 some extended work on these high-phosphorus hot metals at Duisberg. Many blows were made in a 3-ton vessel, and later several 50-ton heats were produced which were of good quality with respect to final nitrogen and phosphorus content. It soon became apparent that the phosphorus content could be controlled by the manner in which the bath was cooled during the blow. When cold scrap was used for cooling, much of the phosphorus remained in the bath until the carbon was all oxidized, and an after-blow was necessary to reduce phosphorus to required level. Additions of about 230 lb. of low-phosphorus, 58% Fe ore per ton (instead of steel scrap) reduced the bath temperature and increased the FeO content of the slag, with the result that phosphorus was oxidized and slagged while the carbon content of the bath was still high (0.50 to 1.00%). The ore also supplied oxygen and reduced the oxygen gas consumption by 30 to 40% and the blowing time proportionally. This different behavior with ore charges is due to the composition of the slag during the blow; when iron ore is added the FeO content of the slag rose rapidly, the solid lime was fluxed more rapidly, and such a slag holds the P_2O_5 strongly. With such ore additions at the end of the blow the metal contains under 0.06% carbon and 0.03% phosphorus. All of this work was done with 2.0% phosphorus iron and it demonstrates that there is good probability that the oxygen converter processes may be extended to almost any type of hot metal.

It is obvious that as the phosphorus in the hot metal rises above 0.30% the amount in the slag increases rapidly, and when pig iron containing as much as 2.0% phosphorus is encountered, the slag becomes very rich. For example, a slag containing 45% lime would then analyze over 23% P_2O_5. In blowing such a bath with oxygen it would be necessary to skim the slag two or three times which would be tedious and expensive. Oxygen consumption would also increase over 40%.

Metallurgists who have studied the top-blown converters state that if the phosphorus level is between 0.30% and 0.80% at least two slags would have to be used (and probably three slags for higher phosphorus). This explains the reason why the old bottom-blown Thomas converters are being blown with oxygen-enriched air, with final stage using pure oxygen with or without CO_2 or H_2O. Apparently this is simpler and cheaper than the full stage blowing with pure oxygen in the oxygen converter for irons containing over 0.30% phosphorus. Since most American pig irons contain less than this, the top-blown oxygen converter is much more adaptable to American conditions than in most situations in Europe.

Swedish metallurgists have also made important contributions to this problem of making low-nitrogen steel from high-phosphorus hot metal. The blowing with mixtures of oxygen and CO_2 has been described by Kalling in connection with his extensive work at Domnarvet works with an oxygen blown rotating converter.* The latter operation is called the Kaldo or Stora Process and 35-ton production units are oper-

**Revue Universelle des Mines*, 1953, p. 612.

ating. Two new installations are reported as under construction at European plants. Rotating of the vessel greatly accelerates the slag-metal reactions, and the removal of phosphorus before the carbon is more readily accomplished. Bath temperature is controlled with scrap or ore additions; less fume is produced since lower oxygen pressures are used for lancing. Figure 3 shows the reduction of carbon and phosphorus for both high and low-phosphorus hot metal in the three important methods of operating basic lined converters.

Oxygen Production

Obviously this spectacular process depends on the manufacture of oxygen in great quantity. Great improvements in cost and purity have been made during the past few years. It can now be made up to 99.5% pure at the rate of 500 tons per day in single plants at a cost of $5.00 per ton. Since less than 200 lb. of gas is required per ton of steel, the oxygen cost is less than 50¢ – only about one quarter the cost of the fuel necessary for melting openhearth steel. An excellent paper by Steele and Cummings in September, 1956, before the Association of Iron and Steel Engineers gives a good description of oxygen plant design, operations and cost. A 500-ton plant costs about $3,500,000 and supplies enough oxygen to make 5000 tons of steel per day. There is no longer any doubt that cheap, high-purity oxygen is readily available.

One of the knottiest problems is related to the very hot gases leaving the mouth of the vessels. They leave the converter about 3000° F.; the volume amounts to about 1800 cu ft. of CO and 200 cu. ft. CO_2 per ton of steel. Dust and fume content has been reported to be about 7 grains per cu.ft. in the hood above the converter, consisting of very fine particles of iron, iron oxide and flux. Since the CO gas burns in the aspirated air, extremely high temperatures would be generated in the hood if a large amount of excess air did not dilute the mixture. Consequently, fans of 125,000 to 150,000 cu.ft. capacity per min. pull about four to five times the amount of air required to burn the carbon monoxide, and this cools the mixture to 1500 to 1600° F. The smoke then passes into large chambers where water sprays of 260 to 300 gal. per min. finally cool it so it can be handled in ordinary gas cleaning equipment. (The three plants now operating are using three different cleaning methods, all of which are reported to be satisfactory.) The gases exhausted from the stack contain between 0.2 and 0.4 grain of solids per cu.ft. It has been reported in several papers that 35 to 50 lb. of dust is collected per ton of steel produced. The volume of gases to be cleaned for a 40-ton heat totals 2,000,000 to 2,500,000 cu.ft., including 1,100,000 cu.ft. of water vapor from the sprays.

The heat potential of these gases is fantastic. It seems a pitiful waste of thermal energy to cool them without recovering a part of their energy, roughly calculated as being over 800,000 Btu. per ton of steel. This heat should generate up to 200 kw-hr. of electricity in an efficient combination of waste heat boiler and steam turbine, and this would be a major fraction of the energy required to produce marketable shapes, estimated by the American Iron and Steel Institute as about 330 kw-hr. per ton of ingots.

It is estimated that oxygen converter steel may be produced from low-phosphorus hot metal for $3 to $5 less per ton of ingots than by other methods, other conditions being similar. The varying cost of raw materials, particularly steel scrap, will greatly influence this differential. For example, when scrap is $30 per ton the oxygen converter steel saves only about $3 over a 50-50 openhearth heat; $60 scrap would raise the favorable differential to over $5 per ton. The question then becomes pertinent: Why not make most of our steel in the oxygen converter and abandon the openhearths as they become decrepit?

This trend may already be appearing, for total ingot capacity of about 10 million tons per year of oxygen converted steel is already planned. However, steel scrap is also an available raw material which will always be used. If 50% of all American steel were eventually made in oxygen converters, the production of 120,000,000 tons of ingots per year would build up an unused surplus of 20,000,000 tons of steel scrap and also require the construction of new blast furnaces making over 20,000,000 tons of pig iron per year. Under these circumstances the price of scrap would fall and the price of iron ore would rise and thus tend to balance the cost of raw materials used in the charge.

These are the conditions which would favor the growth of more electric steel, since scrap is more cheaply melted in large arc furnaces, at lower capital costs, than in openhearths. It certainly appears that the familiar and dominant openhearth furnace will face very stiff competition within the next ten years and our steel executives, who were mostly raised in openhearth shops, may have to take a post graduate course in steel-melting practices!

The French Aluminum Industry

By *GEORGES A. BAUDART**

The lead taken by France's pioneering scientists in aluminum technology has been maintained by their successors. Recent changes in cell design and operations have decreased power requirements by 27%, and man-hours by two thirds. (A4p, C23, F23; Al)

In any statement of the present position of the French aluminum industry it may not be amiss to say something about the honorable place French scientists, engineers and business men have occupied in the earlier history of this light metal. It was the Frenchman Henry Sainte-Claire Deville who, in 1854, invented the first industrial method of production by chemical means. From 1859 to 1889 France was the only country to produce aluminum without interruption. The production center was a factory in Salindres, in the district of Gard, not far from Marseilles. It was another Frenchman, Paul Heroult who, in 1886, at the same time as Charles Martin Hall in America, invented the electrolytic method which is in some minor modifications practically the only one used today.

*Economic Editor, *Revue de l'Aluminium*, Paris, France.

Aluminum From Dark Africa – Airview of Partly Completed Plant at Edea, the Cameroons, With Annual Capacity of 45,000 Metric Tons of Ingot. Below, workmen are siphoning molten metal from electrolytic cell into casting ladle

Bauxite itself, the ore of aluminum, is something like a French invention, since it was discovered in 1821 by Berthier, near the village of Baux in Provence—hence the name.

Production and Consumption

Since the beginning of this century aluminum production in France has been constantly increasing—from 1500 metric tons* in 1900 to 9400 tons in 1910, up to a little less than 26,000 tons in 1930 and a little more than 45,000 tons just before World War II. After the stagnant period of occupation, French production resumed its expansion. While in 1950 only 60,700 tons of metal was produced, by 1952 the figure was 106,000 tons, 120,000 tons in 1954 and nearly 150,000 tons in 1956.

As for consumption within France, it has been calculated that before 1940 it doubled on the average every decade. Since the last war the rate of increase is greater—it doubled between 1950 and 1955, going from 55,000 to 110,000 tons. In 1956 it was around 135,000 tons, leaving some 15,000 tons of ingot for export.

As for the other common nonferrous metals, ore supplies are negligible in France proper. However there are important deposits of bauxite, the principal aluminum ore. Aside from some accessory substances such as coke for electrodes, our industry is in no way dependent on imports from other countries.

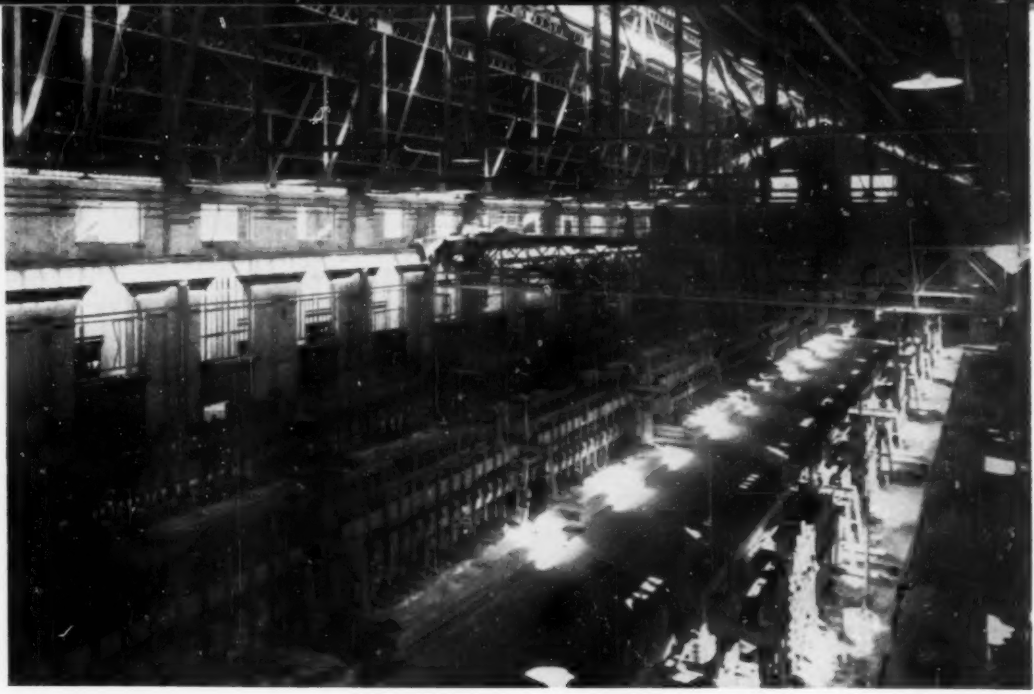
The reasons for this rapid rise in the French aluminum industry are: first, and most important, the interesting and varied properties of the metal; second is the favorable downward trend of manufacturing costs; third is an ever widening appreciation of the possibilities and utilization of this remarkable metal; and finally is notable progress in metallurgy and technology.

Leadership in Technology

In the last category France has made extensive contributions. Improvement of methods and equipment has led to a considerable cost reduction in bauxite mining and extraction of alumina. Take, for example, the Heroult quarry where yield has been increased from 1.3 tons per day per workman as of 1947 to more than 6 tons per man-day in 1957. In the next operation (production of pure alumina, Al_2O_3, for the reduction cells), the cost reduction has been spectacular in the past few years, not only in the man-hours per ton produced but also in the consumption of chemicals. While in 1945 the average was 10.5 man-hours needed per ton of alumina, in 1956 only 2.0 were needed. Steam consumption was reduced simultaneously from 8.5 to 3.8 tons per ton of alumina in the batch process and to 2.5 tons in the continuous process. Possibilities for further progress do not seem to have been exhausted. In fact until recently the standard chemical process for separating oxide was batch by batch, but the newly developed continuous process will undoubtedly lead to new economies as it becomes more highly perfected.

It is, however, in the electrolytic reduction of oxide to metal where the most notable recent progress has been made in France. Whereas in 1938 some 22,000 kw-hr. of electrical energy in the form of continuous current at low voltage was necessary to produce one ton of aluminum, in 1956 this had been reduced to some 17,000 kw-hr. in French pot rooms. This average is still further reduced in the modern equipment of the largest French plant (St. Jean de Mauri-

*1 metric ton = 1.1 short ton at 2000 lb.



Pot Room in Aluminum Reduction Plant at St. Jean de Maurienne; Line Consumes 100,000 Amp. of Direct Current

enne) where energy consumption has fallen to 16,000 kw-hr. per ton of metal produced, which represents a power economy of 27% when compared with average performance in 1938. Continuing their researches on higher-intensity cells, French technicians now are experimenting with cells using 150,000 amp.

Improvements in labor-saving equipment and working methods have also reduced man-hours in the reduction plant from 52 man-hours per ton of aluminum in 1947 (hand work connected with electrolysis, casting, maintenance) to some 15 man-hours.

Results like these have attracted the attention of producers the world over to French factories. The most extensive aluminum industry in the world, that of the United States, came to Pechiney* both to improve its operating methods and to design new plants. Thus, the aluminum plant at Columbia Falls, Mont., owned by Anaconda Copper Mining Co., was built to French plans, and the construction supervised by French engineers. Three other major producers, namely Alcoa, Reynolds Metals Co., and Kaiser Aluminum and Chemical Corp., all entered into contracts with Pechiney for technical information. This was also true for the new producers, Harvey Machine Co. and Olin Mathieson Chemical Corp. In Canada also, an agreement was concluded with Aluminium, Ltd., and it is understood that certain features in their giant factory at Kitimat have been influenced by techniques developed at Saint Jean de Maurienne. In the rest of the world interest has been analogous – Great Britain, South America, and Japan.

The importance of these producers who have sought French aid and their geographic dispersion constitute world-wide recognition of the present leadership of France in this branch of the metallurgical industry.

In fact, these improvements in all phases of production have enabled our aluminum industry to compete with foreign countries which expanded during 1940 to 1945 under extremely favorable financial conditions. It is even a little paradoxical to note that as this is written (midsummer of 1957) the sale price of aluminum in France is below that of the large American and Canadian producers. At a time when aluminum is quoted in the United States (for sale within the country) at 25¢ per lb. (the same price being the price of metal laid down in Europe) the price of French metal is stabilized at 24.7¢ per lb. This result is the more remarkable when the industrial capacity of the three aluminum industries is compared – 165,000 tons in France (and

*The leading French producer of aluminum ingots is Compagnie de Pechiney. It operates a number of plants in France and elsewhere. The main French plant (Pechiney) is at St. Jean de Maurienne in the Province of Savoie in the mountainous country south of the Lake of Geneva.

this not completely utilizable due to lack of electricity) as opposed to nearly 1,700,000 tons in the United States and to about 700,000 tons in Canada. Finally it should not be forgotten that energy – which constitutes a very large share of the production costs – is considerably more expensive in France than in the United States, and that this disparity is even greater for Canada.

The above figures represent principally the production of commercially pure aluminum (99.5% Al, balance mostly silicon and iron). Pechiney's staff at St. Jean de Maurienne have also been leaders in devising equipment for superpurity aluminum (99.99+%), and have been in commercial production since the early 1930's. The production methods and the properties of the really pure metal were fully described in *Metal Progress* last August by Messrs. Bloch and Muller.

Progress in Rolling

Considerable technical progress is also to be noted in the rolling mills, where France again played a pioneer role. Issoire, west of Lyons (together with Alcoa in the United States) early adapted the techniques of continuous rolling, previously used exclusively for steel sheet-strip, to the working of light metals.

Just prior to World War II French engineers designed such an installation which was built in the United States. Parts of this mill were beginning to arrive when the Germans invaded in 1940. Thus the American builders found themselves in possession of complete designs as well as the major elements of this prototype, which was installed in the then new Lister Hill, Ala., plant of Reynolds Metals Co., and from this start several large rolling mills were built. This was an important aid in the mass production of the four-engined bombers which played such a very important part in the war.

It is also proper to note that the first four-high rolling mills were introduced in France in about 1935 for the production of sheet metal 3 ft. wide. Furthermore the idea of making sheets, not one by one, but by cutting them from a long strip came from this early equipment, and this led naturally to the conception of continuous rolling of aluminum sheet. Likewise, it was in France that the first rolling mills to produce sheet of variable thickness were designed and built in 1937. The importance of such a development to aeronautics is clear – for instance in the rolling of metal for airplane wings, where the distribution of stresses naturally requires progressive variation of the dimensions of structural elements. When the Americans tackled this problem in 1950, they were aided by the existing French techniques.

While the rapid process annealing of aluminum alloy strip offers few difficulties*, a more precise heat treatment of the age hardenable alloys used for aircraft is much more difficult. Nevertheless, as shown in an article by Marcel Lamourdedieu in *Metal Progress* for October 1951 the Issoire management (La Compagnie Generale du Duralumin et du Cuivre) contracted with United Engineering and Foundry Co. in New Castle, Pa., for a thorough study of the problem which resulted in a completely satisfactory plant which has been operating since 1952.

But industrial history is made not only by technical innovations. It is more deeply rooted. Sometimes it requires political audacity. It is within this perspective that French projects in Africa should be viewed. While traditional colonialism would use black Africa only as a source for raw materials, French industrialists were the first to plan a complete manufacturing cycle for aluminum. On Feb. 1, 1957, an electrolytic plant was started at Edea, in the Cameroons. This plant, the first of its kind in the African continent, will reach full capacity, about 45,000 tons per year, in 1958.

Along the same lines, studies are going on looking toward building plants in French Guinea and Middle Congo which will deal with the three phases of production, mining of bauxite, purification of alumina, reduction of aluminum. Some years from now, a plant with an initial capacity of 480,000 tons per year of alumina will be operating in Fria, in Guinea; reduction of aluminum should follow shortly afterward.

The Guinea and Middle Congo projects will be undertaken with international participation, and the active interest shown by Olin Mathieson in the United States and by Aluminium Ltd. in Canada in these new plans shows that diverse producers have the same fundamental ideas about Africa. After the Egyptian affair, when occidental solidarity seemed momentarily in doubt, collaboration in Black Africa shows that politically as well as technically France is capable of introducing positive solutions to present-day problems.

*See "Induction Heating for Continuous Heat Treatment of Sheet and Strip" by F. C. Hull and Howard Scott, *Metal Progress*, February 1952, p. 57.

Nuclear Power in Europe

By ANDREW W. KRAMER*

Limited conventional fuel and energy resources of Europe mean that nuclear power there is much more necessary than in the United States. Great Britain is already launched on an ambitious program and the formation of the European Atomic Energy Community by six of the central European nations will hasten nuclear power development on the continent. (A11, W11p, 16-62)

ON MARCH 25, 1957, in the Hall of Hotatii and Curiatti on Capitol Hill in Rome, Italy, the Chancellor of West Germany, the prime ministers of Italy and Luxembourg, and the foreign ministers of Belgium, France, and the Netherlands affixed their signatures to a "Treaty Instituting the European Atomic Energy Community". Despite many other important happenings in the field of nuclear energy in Europe, particularly in England, the signing of this "Euratom" treaty may prove to have been the most outstanding development of the year.

To understand its importance it is necessary only to describe briefly the critical situation in which western Europe finds itself. Unlike the United States, which still has ample fossil fuel resources (coal, petroleum, natural gas), Europe needs nuclear power now, and the Europeans know that if they do not get it as quickly as humanly and technologically possible their nations will face disaster. In the 19th Century, cheap and abundant coal turned Europe into the workshop of the world. In the last five years of postwar expansion, however, Europe has suddenly discovered that this favorable situation has changed entirely, and that this conditions all its prospects; the shortage of energy threatens to become a major brake on economic growth.

In 1870, the entire world mined some 218,000,000 tons of coal. Of this the United Kingdom and the six European countries now comprising the European Community of Atomic Energy (Euratom) produced three quarters. Today, though the six European countries mine more coal than the entire world in 1870, they provide only 15% of the world's energy. They now import nearly a quarter of their energy supplies, most of which is in the form of oil from the Middle East – the equivalent of 100,000,000 tons of coal a year. The Suez crisis demonstrated how precarious this situation is.

With the steady rate of economic expansion to be expected, and in the absence of atomic power, the six Euratom countries would be importing around 200,000,000 tons or 33% of their requirements in 1967 – just nine years from now. Ten years after that, in 1977, the graph shows that energy imports would reach 300,000,000 tons or 40% of the total requirements.

This affects the whole of Europe's economic growth – indeed even the political security of the world. First the figures imply an annual bill for energy imports rising from $2,000,000 at present to $4,000,000 by 1967, and $6,000,000 by 1975. Even assuming that part of this could be paid in national currency, raising the additional foreign capital needed would impose a grave – even impossible – burden on the economic structure of these countries. A second still more serious threat is the evidence provided by recent political events and the ensuing oil shortage that even the *availability* of imported oil is uncertain. Without nuclear power Europe's dependence on the Middle East for energy supplies is bound to increase. The Suez crisis gave warning of what this could mean and the European governments are determined that such a precarious situation shall not prevail again.

In Europe, as in America, electric power consumption is doubling every ten years. The capacity of power stations in the six countries is expected to rise from 38,000,000 kw. at the end of 1960 to 60,500,000 kw. by the end of 1967.

*Editor, *Power Engineering*, Chicago.

This is the field into which nuclear power can be fitted.

From all this it should be clear why, under Euratom, the six European countries have undertaken to build 15,000,000 kw. of nuclear power capacity during the next ten years. If this can be done (and every effort will be made to do it) it will stabilize imports at a level they would otherwise reach in 1963 of 165,000,000 tons of coal equivalent a year. This is an ambitious target and it will call for a great continuous effort since none of the European industries except the French have had any experience in the field. Indeed this ambitious program in western Europe is of considerable significance to American manufacturers, provided the American nucleonic and electrical industries are able to supply the market at competitive prices.

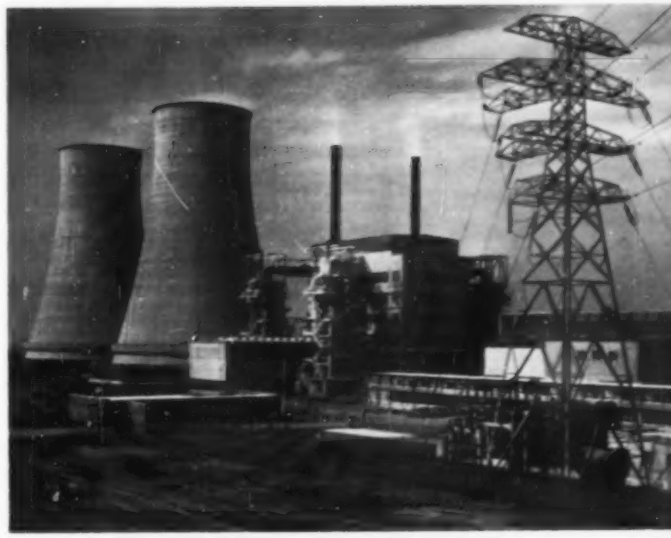
Britain's Progress in Nuclear Power

Great Britain has already faced a similar issue and has come to the same conclusion as the Euratom countries. In fact, the British have reacted very quickly to an energy shortage less threatening than on the continent. Britain expects to install some 6,000,000 kw. of nuclear power by 1965, and to do the job herself.

A little over a year ago, on Oct. 17, 1956, Queen Elizabeth opened the world's first large atomic power station at Calder Hall in Cumberland, England.* At that time Britain had already planned an extensive nuclear power program for the next decade, but since the Calder Hall plant has performed so well this program has been trebled. Four purely commercial nuclear power plants have been started and the proposed site for another has been announced. (By "purely commercial" is meant that production of explosive material is not a vital adjunct.) In 1954 an experimental fast breeder reactor was started at Harwell, and it was announced that a large version for power generation was to be built at Dounreay in Scotland. This plant will go critical early in 1958.

Britain's progress in the nuclear power field has therefore been astonishing. It was only 12 years ago, Oct. 29, 1945, that the decision was made to embark on an atomic energy program. The first step was to set up a research establishment at Harwell under the leadership of Sir John Cockcroft. In the following decade was built every type of plant necessary to derive the physical and engineering data; 13 reactors are now operating and at least ten more are being built – all on behalf of the British Atomic Energy Authority. Apart from this, private industry is building eight power reactors and others are proposed in the near future. The first private research reactor is also under construction. Thus, in a short 12 years Britain has changed from a country having no atomic industry, other than that connected with weapons, and only a few technicians with any knowledge of the peacetime possibilities, into one of the world's leading nations in industrial nucleonics.

*See *Metal Progress* for June 1957, p. 65, for an account of some metallurgical problems involved.



Calder Hall "A" Is Dominated by Two Cooling Towers for Condenser Water. Tall building in center contains one reactor; the two scaffoldings surround heat exchangers; two more are on the opposite side. The low long building at right houses the electrical generators. A twin reactor and four heat exchangers are placed at the right end of the power house

The Calder Hall type of gas cooled, natural uranium reactor was so promising, even in the design stages, that other plants of the same nature formed the basis of a nuclear power program announced by the Government in February 1955. This program involved 12 reactors over the next ten years to be built at a cost of £300,-000,000 ($850,000,000) to generate some 2000 megawatts of electricity. Early last year (1957) however, it became so clear that the Calder Hall type of reactor was a success that the original program was trebled to give an output of between 5000 and 6000 megawatts by 1965. Cost per kilowatt delivered is anticipated to be comparable with that of conventional generating

stations. This program, when completed, will save some 18,000,000 tons of coal a year.

More specifically, Sir Christopher Hinton of the U.K. Atomic Energy Authority in an address in March 1957 before the Royal Swedish Academy of Engineering Sciences noted that the 765° F. exit temperatures of the gas in the Calder Hall reactors can reasonably be expected to be increased to 840° F. by 1965, and with further improvements in design and materials to 930° F. by 1970. Heat interchangers and steam turbines will also certainly be improved in efficiency, and plant costs will decrease with constructional experience. On the other hand, cost of coal is bound to increase with the rapid exhaustion of favorable seams. Hence he computes that the relative costs of power from atomic energy and from steam plants of comparable modernity, size and load factor will be as follows (in pence per kw. sent out):

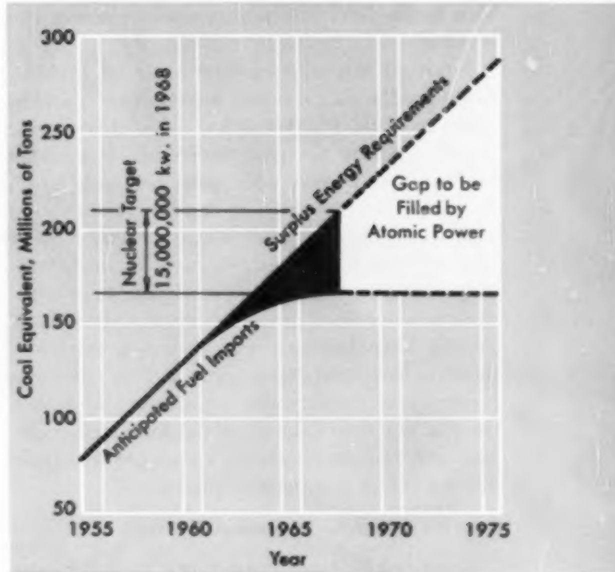
	Atomic	Coal
Present	0.8	0.57
1960	0.66	0.60
1970	0.47	0.67
1980	0.38	0.73
1990	0.32	0.84

It will be observed that the crossing point in England is toward the middle of the 1960 decade – less than ten years hence.

Work has already begun on four of the new stations, namely, at Bradwell, in Essex; at Berkeley, in Gloucestershire; at Hunterston, on the Ayrshire coast of Scotland; and at Hinckley Point in Somerset. The first three are in the 300-megawatt class, whereas the Hinckley Point station will generate on the order of 500 megawatts. However it is not likely to be the largest nuclear power station in the world very long because two other stations are to be ordered in March 1958 as big as 800 megawatts.

Because of the very large contracts that would be available for industry connected with the building of these power stations – contracts running from £35,000,000 to £60,000,000 ($100,000,000 to $175,000,000) – the Atomic Energy Authority encouraged large commercial firms to form themselves into suitable groups or "consortia" capable of tendering bids for complete nuclear power stations. Now there are five such groups in England.

Britain was also the first country to investigate the possible peacetime applications of the fusion process, and recently an important piece of equipment for research in this field was completed at Harwell. It is a large torus or doughnut known as ZETA. Rumor has it that this apparatus has achieved temperatures of 5,000,000° for brief periods (milliseconds), and produced a truly thermonuclear reaction.



Energy Imports of the Six Countries Forming the Euratom Community (France, West Germany, Italy, Belgium, Netherlands and Luxembourg)

Continental European Nuclear Development

France – the year 1957 can be considered an important one for the development of atomic energy in France. A transition occurred from first necessary preparatory steps to the building up of sizable atomic power plant. This transition appears clearly in the five-year plan recently approved by the French Parliament.

France needs energy rather badly. Half of its hydro-electric power is already harnessed; its coal production has come to a limit; most of its dependable oil resources are far from its metropolitan territory. On the other hand, the whole of the electric energy in France is produced and distributed by a public authority "Electricité de France". For these reasons it has been decided that future planning should be done by joint action of the Commissariat à l'Energie Atomique and Electricité de France. France will also participate in Euratom's project and intends to join other projects initiated in this field such as the proposed International Atomic Agency.

While France has considerable uranium and thorium resources which are being developed,

the situation regarding enriched material has been difficult, as in all European countries outside England and Russia. This fact, more than any other argument, forced France to move into the natural uranium reactor techniques. Fortunately, plutonium will be available from the Marcoule reactor in a few months. The 40-mw. reactor "G 1" at that point has been operating steadily and a large plant for processing irradiated fuel, also situated at Marcoule, is virtually completed. When the "G 2" and "G 3" reactors go into action in 1958, the plutonium production of the Marcoule center will be over 100 kg. (220 lb.) a year. Small amounts of U^{233} should also be available because a certain number of thorium fuel elements are being irradiated in the G 1 reactor.

The situation as to U^{235} has greatly improved, primarily because of an agreement for the delivery of 2500 kg. of U^{235} from the United States within ten years. The French, however, are reluctant to continue to rely on overseas supplies for such a vital product, so elaborate research has been performed in France on gaseous diffusion. It now seems probable that France will build (either alone or with its Euratom partners) such an isotope separation plant.

The first series of French power reactors will be built using natural uranium, graphite moderated and of the gas cooled type. Their attitude toward various types of power reactors, however, is by no means dogmatic. They believe that, for the time being, reactors using natural uranium or slightly enriched uranium are well suited for European economics. They have spent about $250,000,000 in ten years on studying reactors using natural uranium and it is, therefore, logical for them to continue to develop this type, even if enriched reactors prove to be as good. This, of course, does not exclude the use of slightly enriched fuel to increase the net performance.

Absence of dogmatism in French reactor development is illustrated by the fact that the new "EDF 1" reactor being built in the Loire Valley is entirely different from the G 2 and G 3 twins at Marcoule which operate on natural uranium and are graphite moderated, carbon dioxide cooled, and have horizontal channels. The overall dimensions of the EDF 1 core are almost identical but the channels are vertical and the lattice pattern is different. The working pressure in G 2 and G 3 will be 15 atm. (220 psi.) and the pressure vessel is a horizontal cylinder of prestressed concrete with a thin steel inside lining to provide gas tightness. On the other hand, the working pressure in EDF 1 will be as high as 25 atm. (355 psi.) and the pressure vessel will be a vertical cylinder of 4-in. steel. The exit temperature of the hot gas will be the same in both reactors (355° C. or 670° F.). In G 2 the heat exchangers are outside the reactor building whereas in EDF 1 they are enclosed in a concrete shield adjacent to the reactor. The G 2 building is a light one, the EDF 1 building is a containment sphere. G 2 will deliver 30 mw. net electric power; from EDF 1 will come 60 mw.

The reason for the difference in these two gas cooled reactor types is that the scientists wanted to know which solution was best, so they decided to test both. Following EDF 1, EDF 2 will go critical some 18 months later. It is of the same general type but with improved design. Its power probably will be three times that of EDF 1, nearly 200-mw. electric.

The proposed target of 850-mw. electric energy of nuclear origin to be installed in France before 1965 will most probably be reached by increasing the size of the successive units rather than by multiplying units of moderate size.

Commissariat a l'Energie Atomique is also giving attention to power reactors moderated with heavy water. French scientists have acquired considerable knowledge in this area from their four heavy water research reactors: the old Chatillon reactor which in 1957 used sintered uranium oxide as fuel; EL 2 in Saclay which was the original heavy-water moderated, carbon dioxide cooled reactor; EL 3, the new 15 - mw. high-flux reactor which became critical in Saclay in mid-1957; and finally, the critical facility "Aquilon", where heavy water lattices have been studied for more than a year.

French scientists and engineers are also studying the use of beryllium oxide as a moderator. The possibility of using sodium as a coolant, and consequently enriched uranium as a fuel, with either graphite or beryllium oxide as moderator, is also being studied.

Lastly, France, after she produces enough plutonium, will start studying fast breeder reactors as soon as possible, but much more will be gained through American and British work. The first fast neutron reactor built in France will be no more than a small experiment.

Norway – The program for development of atomic energy in Norway is being carried out in the Atomic Energy Establishment at Kjeller, north of Oslo, where a natural uranium research reactor moderated with heavy water has been

running since 1951. Activities centered at Kjeller include reactor engineering, reactor physics, chemistry, isotope production, and ship propulsion. They have a staff of 200, of which about 30 are foreign scientists, mostly from the Netherlands, Norway's partner in the operation which is called the "Joint Establishment for Nuclear Energy Research".

A second semi-industrial reactor is now nearing completion. This will eventually deliver steam to a paper pulp factory and may be the forerunner of many similar reactors for this industry. An industrial atomic energy company has recently been organized and this should be instrumental in introducing atomic energy to Norwegian industry and also be at the disposal of foreign industry.

The future of atomic energy in Norway is to a large extent determined by its economic conditions and its geography. One of the largest earners of foreign currency in Norway is shipping. Thus, the principal task in the future will be the construction of reactors suitable for ship propulsion and the training of scientists and technicians required for the operation of a merchant marine propelled by atomic energy.

On land, however, the situation is quite different. Only about 20% of Norway's formidable hydro-electric resources have been developed. Consequently the use of nuclear energy for the production of electricity is a matter for the future. However attention is being devoted to the use of steam produced by atomic energy for paper production – another major industry.

Sweden – As early as 1946, the Swedish Atomic Energy Committee proposed a special organization to take care of industrial projects connected with atomic energy. To facilitate cooperation between the various Swedish industries the Atomic Energy Company was organized jointly by Government and private industry. The State owns 57% and private industry 43% of the shares, which are valued at 14,000,000 kroner ($2,800,000).

Sweden's first experimental reactor was started in the summer of 1954 in an underground laboratory in Stockholm. Known as "R 1", this has about three tons of uranium metal rods, canned in aluminum, hanging down into a tank containing about five tons of heavy water. The designed power level is 300 kw., but it has been run continuously at 600 kw.

Besides the R 1, the Company also carried out exponential experiments in an assembly called "ZEBRA" (Zero Energy Bare Reactor Assembly). So much valuable information has been derived that the company plans to have a permanent installation for both exponential experiments and criticality tests at a new research center at Studsvik, and for this center a material testing reactor "R 2" is scheduled to go into operation at the end of 1958.

The main work on industrial reactors has been carried out for a reactor called "R 3a", with 76-mw. heat output for district heating. This is sufficient for a city of 30,000 inhabitants. The reactor is designed in such a way that it can also be used for the production of 14 mw. of electricity by back-pressure turbines. R 3a will be built in collaboration with the city of Stockholm and is scheduled to go into operation in 1960. It is expected to provide data for subsequent projects – for example, steam-producing reactors for the pulp and paper industry.

The State Power Board has also organized a department of atomic energy and plans a station called "ADAM" of about 75-mw. heat output for the city of Vasteras, scheduled to be in operation in 1960. The Atomic Energy Company and the State Power Board are also collaborating on the first power plant "EVA" which will also use natural uranium and heavy water.

Denmark must import more than 90% of her fuel, and like other industrialized communities has a steadily growing need for energy. In addition, the industrial possibilities opened by atomic energy are of interest to the expanding manufacturing industry.

As a consequence the Government established the Danish Atomic Commission in December 1955 to promote the development for industrial purposes of the new source of energy. In the short intervening time the Commission has turned its attention to planning and constructing a research establishment at Riscoe, near Copenhagen, comprising a number of laboratories and a small research reactor (in operation since August 1957). A larger reactor will be completed early in 1958. Both of the reactors, which are of American make, have been purchased with assistance from the United States under a bilateral agreement. Furthermore, the site is now being opened for the construction of a materials testing reactor of the "Pluto" type, purchased from England in conformity with the Anglo-Danish cooperation agreement.

At the research establishment, scientists and technicians of all categories will familiarize themselves with the new techniques, and expand original research in the hope that Denmark may

also contribute to the industrial development of nuclear energy. Power reactors are as yet for future planning.

Italy – The energy balance (or rather, unbalance) in Italy is typical of other industrial nations – even exaggerated in some respects. From 1922 to 1925 electric power demand in Italy, despite the political crisis and the consequences of World War 1, increased about 7% annually. This rate of growth actually reached close to 9% per year from 1950 to 1955, and in 1956 Italy produced over 40.5 billion kw-hr. of electric power. So far as the future is concerned, it appears reasonable to assume a 7% annual rate of increase in electric power demand, equivalent to doubling the requirements every ten years. Thus, Italy ca: forecast a need for 76 billion kw-hr. in 1965 and 152 billion in 1975.

Studies indicate that Italy's hydro-electric and geotherm-electric* power production and her very small resources in coal and liquid fuel cannot begin to meet these future demands. Even in 1965 the power shortage would amount to several billion kilowatt-hours. Since conventional fuels are three times as expensive in Italy as in the United States, it appears that the only logical answer is nuclear power.

Italy is therefore interested in finding a rapid solution and is laying the ground for an adequate developmental program. The planning, the designing and the building of a new type of atomic energy station call for *time* – that is, from 4 to 5 years. Thus, plants now in the planning stage cannot go on the line before 1961 or 1962, while those of the second generation, put on the drafting table after 1960 using experience acquired with the first ones, will not be ready before 1965. This is just the date when Italy should be in a position to produce electric power from nuclear energy on a large scale.

For these reasons, Edisonvolta Co. of the Edison Group of Milan decided in 1955 to build first an atomic electric power plant of high capacity. The exact type of reactor has not been chosen, but the plant will be built in industrialized northern Italy. Another company has been formed with State-controlled concerns to build another nuclear power station in the south; in this case also the type of reactor has not been chosen.

Other plans have been announced: In the spring of 1956 Fiat and Montecatini set up a new joint company, "SORIN", for research, experimental equipment, and construction of plants for industrial use. Finally, a new state-controlled company, "SIMEA", has announced its intention of building a second large atomic power station in southern Italy, and "Agrip Nucleare", an associated group, intends to build a Calder Hall type of reactor in northern Italy. About 3000 mw. will probably be installed by 1965 in atomic power plants in Italy.

Such a variety of initiatives look promising. Italians believe that maximum freedom is essential to find the best reactor for each situation.

*Derived from hot springs and volcanic regions.

Development in Other European Countries

Switzerland, Germany, Spain, Belgium, and Holland all are making plans for nuclear power. A 150-mw. Calder Hall type of power plant is planned for North Brabant in Holland. Gross-Welzheim on the Main River will be the site of the 15-mw. power reactor in Germany – Germany's first.

Belgium has a 3-mw., natural uranium, graphite moderated, air cooled reactor in operation and a 50-mw. high flux testing reactor under construction. Work is also in progress on a prototype pressurized water reactor of 11 mw. electric capacity. A tentative program has as its goal the construction of some 540 mw. of nuclear capacity in Belgium by 1967.

Switzerland has several research reactors in operation or under construction and a small power reactor, the first in that country, is to be built in Lausanne in time to furnish electricity for the 1964 Swiss National Exhibition. Having neither coal nor oil resources, hydro-electric plants in Switzerland are the mainstays, but when the last dams now under construction in the high Alps are completed in a year or two, the country will have no further hydro-electric potential. Atomic power, therefore, becomes imperative.

In Spain an Atomic Energy Junta is entrusted with all research and development work in the nuclear field and to advise the government. A swimming pool type reactor developing 3000 kw. of heat is being delivered by International General Electric and will be ready for operation in the spring of 1958. Authorization has been asked for a second reactor for the testing of materials and for sufficient heat to generate 20,000 kw. of electricity. The consumption of electricity in Spain is increasing at a higher rate than in any other European country, amounting to 8.5% annually, yet the country is poor in fossil fuels and her hydro-electric resources will be completely harnessed within ten years.

Russia – In early summer of 1956 a group of Soviet engineers (headed by the politician Malenkov) visited British installations and in return a score of Britishers (headed by the chairman of the Central Electricity Authority) inspected the electricity supply in the U.S.S.R. This group visited the 5000-kw. experimental power station which was described in paper P/615 before the 1955 Geneva conference. It started operation in June 1954. It uses enriched uranium; the neutrons are moderated by graphite; the reactor is cooled with water (exit temperature about 500° F.) The visitors reported that "the standard of engineering throughout is of a very high order".

Several ministries have their fingers in the pie, but coordination is expected through a new Ministry of Power Stations. The Academy of Sciences, which has charge of the small station and much if not all the experimental development, has determined the types of reactors which shall be built. The immense 1956-1960 five-year plan for electrical expansion in the U.S.S.R. includes a total of 2000 to 2500 megawatts of electrical output from atomic energy plants. These are to be located near large cities where the heat from the low-pressure stages in the turbines can be used for district heating projects rather than wasted. These reactors will include one 70,000,000-kw. unit of the design described above to be operating by the end of 1958. Two others of similar size will be water moderated and water cooled. The third type was described before the National Industrial Conference Board in New York in 1955 as moderated by heavy water and gas cooled. Toward the end of the five-year plan it is hoped to have at least four smaller plants generating 50,000 to 70,000 kw. (of heat?); one will feed hot radioactive steam direct from reactor to turbine; another will be graphite moderated and sodium cooled; a third will be a fast breeder reactor sodium cooled; the fourth a thermal breeder containing a solution of U^{233} in heavy water. Design of future large plants will depend on the operational data from these various plants.

The British engineers point out that approved Russian projects pay no interest on capital charges; in general, "money" as we know it has no meaning if some top bureaucrat decides that a certain thing should be built. Hence, it does not follow that a successfully operating plant in Russia could be made to pay in some part of the free world. Furthermore, due to the severe winters and the poor transportation system, a reactor might be prescribed for a region where they find it difficult to deliver fossil fuels found in relative abundance at a little distance.

Euratom–What It Means

Whether the ambitious goal of 15,000,000 kw. of nuclear power by 1967 set forth by the Euratom group can be achieved is still open to question but informed and responsible opinion in most of the countries is that this goal is feasible. Only the German and Italian representatives report any skepticism. Whether or not the grand total can be attained by that time, however, is of less importance at the present time than the fact that the necessary organization has been set up. It constitutes one further step in the industrial and scientific integration which is so vitally needed in Europe. The six countries (France, Italy, West Germany, Belgium, Netherlands, Luxembourg) are already linked in the European Coal and Steel Community, and Euratom is one further step in the creation of a common market and a large free trade area.

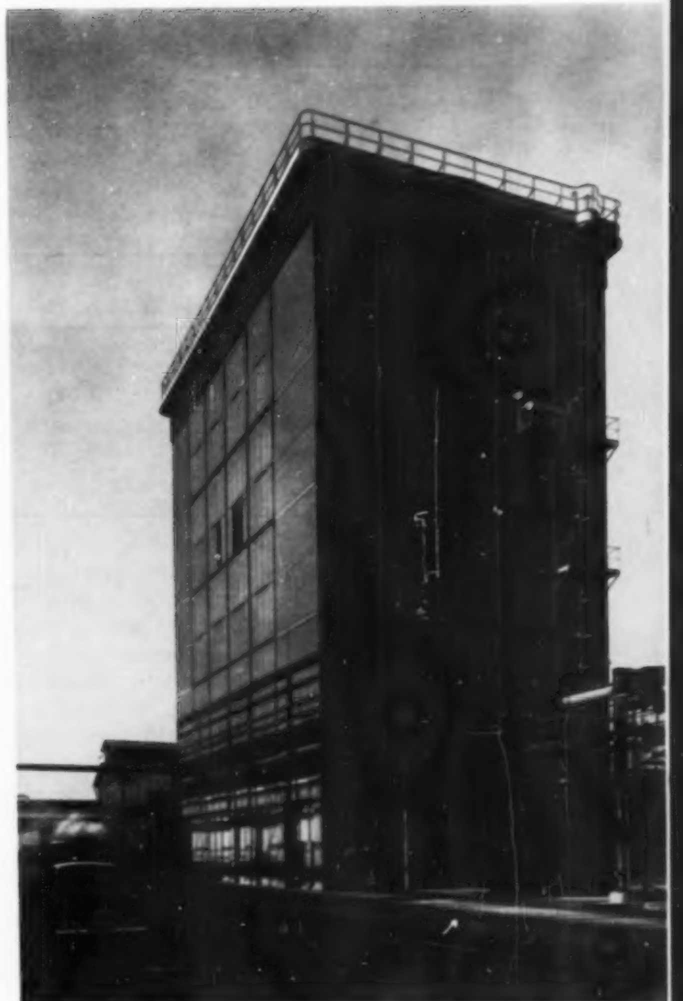
By creating the conditions required for the speedy formation and development of nuclear industries, the living standards in the member states will be raised and trade with other countries promoted. Euratom aims to promote and coordinate research, to institute training programs, to set up an institution or university for the training of nuclear specialists, to obtain licenses and exploit patentable inventions. It will coordinate the supply of ores, raw materials, and fissionable material on the principle of equal access to resources.

Euratom will create new opportunities. It will pool the scientific and the industrial resources of the six countries as well as their varied skills. Finally, Euratom will represent the six nations as a single unit in its dealings with other governments, and will be in a far better position to obtain full cooperation from them than if each member acted separately. Euratom's contribution in nuclear fuels, reactor technology and components can make the difference between a rapid and a slow European development. The situation in Europe is critical. Nuclear power has moved out of the scientist's laboratory onto the engineer's drawing board and will quickly be commercially produced. Since history amply proves how difficult it is for the European countries to act in unison, Euratom offers them an opportunity to proceed as a highly effective single unit toward the only solution of their future energy problems.

Continuous Casting of Gray Iron

By *ADALBERT WITTMOSER**

Rounds, and especially tubes, of gray iron are now cast in a collar mold and slowly withdrawn downward in tempo with the pouring rate. Gas and water pipe in sizes up to 3 ft. diameter and 33 ft. long, as well as large cylinder liners, are being made in quantity in a West German foundry. (D9q; CI-n)



Plant for Continuous Casting of Pipe and Long Bars at Eisenwerke Gelsenkirchen

Mass production methods for casting the commercial types of gray iron appear to favor molding materials of durability and relative permanence. The ever-increasing demands for greater accuracy of rough castings have led to the invention of precision methods such as shell molding and the lost wax process. However, such efforts to reduce tolerances and increase surface accuracy are but transition steps toward the ultimate goal in precision obtained by permanent metal molds (or graphite molds in special instances). The following listing classifies the different methods of casting depending on surface smoothness – roughest at top, smoothest at bottom.

Dry sand
Green sand
Cement molds, CO_2 process
Shell molds
Lost wax or investment casting
Lined metal molds
Permanent molds

Of the different methods of casting in permanent molds, the stationary process is the oldest for gray iron, as well as for other cast metals. However, only a relatively small percentage of

*Director of Research, Eisenwerke Gelsenkirchen, Gelsenkirchen, West Germany. This paper is an adaptation of one presented to the 1957 International Foundry Congress at Dusseldorf.

Table I – Physical Properties of Representative Foundry Alloys (Basis, Cast Iron = 100)

	Cast Iron	Steel	Copper	Aluminum
Disposable heat	100	116	92	59
Pouring temperature	100	107	83	48
Thermal conductivity	100	122	1640	1380
Economically feasible pouring speed	100	92	6.6	39

Table II – Properties of 16-In. Pipe

	Sand Cast	Centrifugal	Continuous
Analysis: Carbon	3.42%	3.39%	3.46%
Silicon	1.68	1.97	2.09
Tensile strength	22,000 psi.	31,500 psi.	38,000 psi.
Bend test: Strength	51,000 psi.	51,000 psi.	70,000 psi.
Deflection	3.6 mm.	3.3 mm.	3.5 mm.
Brinell hardness	208	203	215

the over-all production of such parts has been in gray iron; the applications comprise principally pressure-tight automotive and hydraulic parts. Practically no iron is die cast, the method having been limited almost exclusively to low-melting alloys. As far as is known to the writer no success has been achieved as yet with permanent molds other than in the laboratory.

Conversely, centrifugal casting – one use of the lined metal mold – has found its most extensive use for cast iron parts in tonnage, because an almost fully mechanized procedure of this sort is most economical for producing cast iron pipe. The extremely rapid growth of urban centers of population causes an ever-expanding need for water and gas systems, and in Germany the production of centrifugally cast pipe now accounts for more than 15% of the gross gray iron tonnage.

In view of this technical and economic importance of centrifugal casting it seems astonishing that the continuous casting of bars, rods and tubes has been so long neglected. Both the centrifugal and continuous processes have this in common: The parts produced should have a uniform cross-sectional area over their length (except for a flange or such like at the leading end). To counterbalance this limitation, continuous casting has the following advantages when compared to centrifugal processes:

1. It is the only method which utilizes an uninterrupted flow of metal and is therefore best adapted to mass fabrication. It also eliminates (or at least minimizes) microstructural differences throughout the body of the cast part.

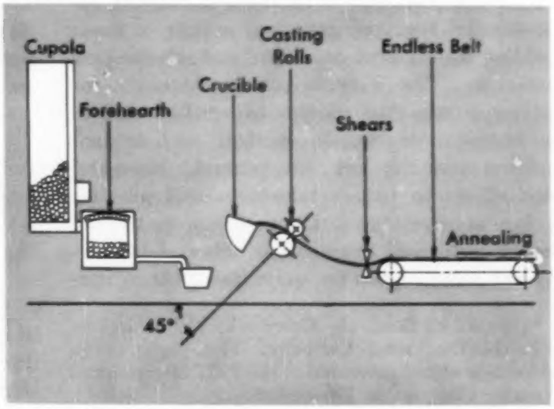
2. Cost of the metal mold and its maintenance is lower than the other processes. The dimensions of the mold or die match the cross section of the part produced, whereas its length axially is only a fraction of the over-all length of the casting. The latter is limited only by the height of the casting machine and the capacity of the melting equipment used.

3. Die wear is relatively insignificant. The most important prerequisite for successful exploitation of the continuous casting process for iron-carbon alloys seems to have been missing thus far, namely a ready market justifying mass fabrication of plate, bar, or tubes. It seemed that bars of cylindrical cross section could be used for bearings and bushings, but German foundries failed to overcome the sales reistance of consumers and fabricators. Introduction and further development of a commercial process were therefore halted.

In addition, the synopsis of physical property data in Table I shows that conditions are far less favorable for continuous casting of gray iron than they are for either copper or the light metal alloys.

A search of authoritative technical literature then available also revealed that continuous casting of gray iron had been accomplished only in isolated cases and hardly exceeded the status

Fig. 1 – Russian Scheme for Continuous Casting of Gray Iron Sheet. (L. Andrejew, Hutnik, *Vol. 18, 1951, p. 463)*



of a laboratory curiosity. Russian investigators had described a project to make 2-mm. gage sheets (0.079 in.) by a combination process involving both casting and rolling (Fig. 1). It was claimed that the resulting "sheet" could be deep drawn and was suitable for corrosion resistant roofing. Only two serious discussions of continuous casting (one Russian, one English*) appeared in the literature between 1952 and 1954. They dealt with the successful casting of solid billets measuring 20 to 100 mm. in diameter and up to 2 m. in length (0.75 to 4.0 in., up to 6.5 ft. in length).

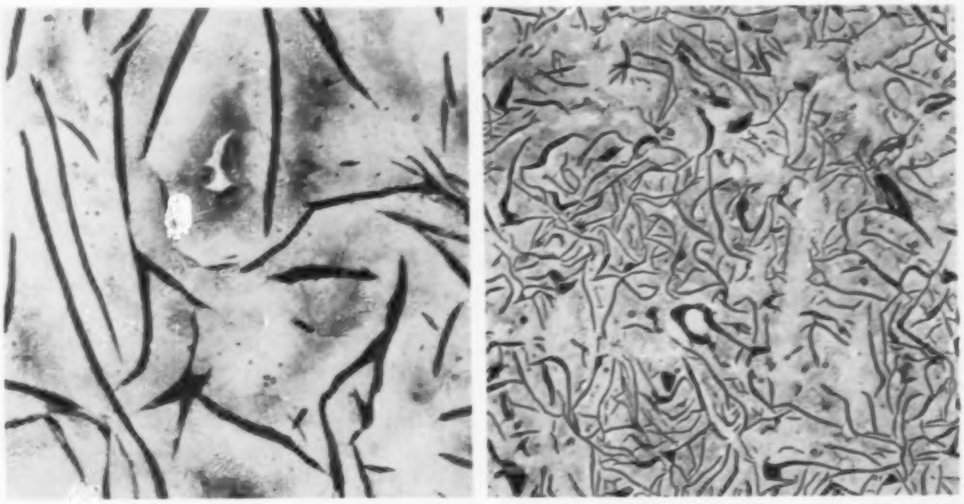


Fig. 2 – Microstructures at Same Magnification of Mold for Centrifugal Casting Machines Near the Center of a 9-In. Round. Left is sand cast; right is continuously cast

Problems to Be Solved

Although the future for continuous iron castings looked rather bleak, the thought persisted that certain items, especially pipe of large diameter, would lend themselves to successful production by this process. Pursuing this idea a team of scientists of the Eisenwerke Gelsenkirchen, under the direction of Dr. Niedenthal, was fortunately able to develop a valuable contribution to the art. Much of the output of this company is cast iron pipe. The firm had also pioneered in the introduction of the DeLavaud process in the early 1920's, using a water-cooled metal mold. Since then pressure-tight cast iron pipe for gas and water lines, 2 in. to 2 ft. in diameter and up to 20 ft. in length, has been cast exclusively by this method. However, in any successful application of continuous casting a number of serious difficulties had to be overcome:

1. The technical feasibility of continuous casting of gray iron had not previously been explored.

2. Only semifinished parts had thus far been cast continuously; that is, the surface condition was subsequently improved by machining or grinding. Would it be possible to cast gray iron continuously and obtain a quality of the unmachined surface sufficiently good to give a product that would be salable?

3. Most experts on continuous casting practices were doubtful that it would be possible to cast hollow tubes with walls between 0.40 and 0.75 in. thick and diameters up to and in excess of 3 ft. Such a ratio of wall thickness to diameter was unlike anything previously made in more tractable metals and alloys.

Clearly recognizing that the development of a commercial practice for continuous casting of iron alloys needed all available knowledge and experience, Eisenwerke Gelsenkirchen obtained the services of the pioneer in this field, Dr. S. Junghans of Schorndorf, who made initial trials on 15-in. diameter pipes in his own engineering experiment station.

Pilot Plant Results

At the successful conclusion of the original test run it appeared prudent to transfer further systematic work to the plant in Gelsenkirchen

Machinery (London), Vol. 84, 1954, p. 506.

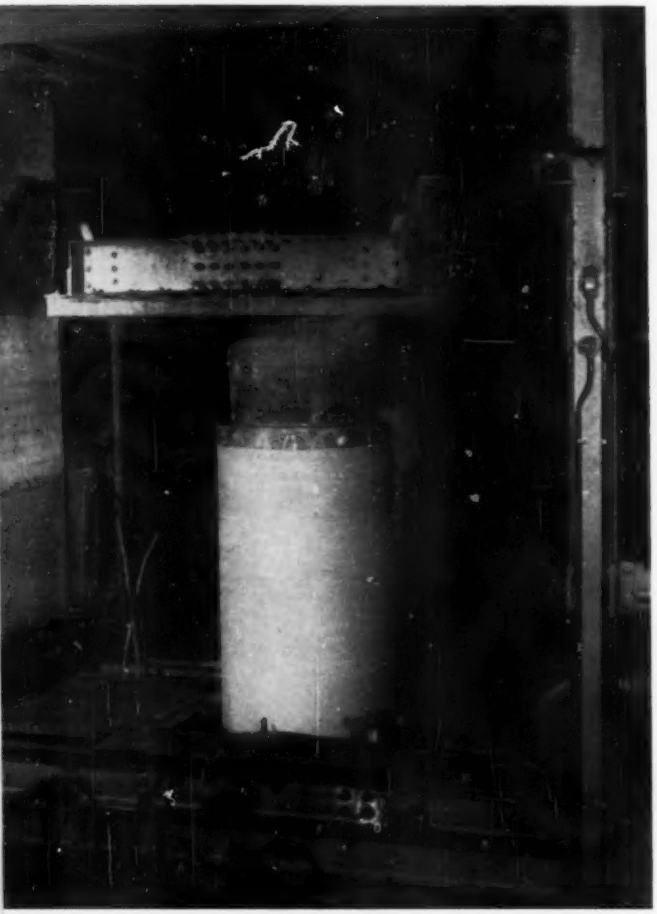


Fig. 3 – Lower Portion of Machine During Casting of a 40-In. Tube

and carry out a series of investigations under conditions designed to lead to the economical production of solid and hollow shapes of varying dimensions. A pilot plant was built for such items up to 60 in. outside diameter and 10 ft. long. It became possible, in time, to improve the surface appearance of the bars and to raise the casting speed without sacrifice in quality. Ultimately pipe 12 in. in diameter was produced free from any flaw and meeting close dimensional specifications. Examples of the work turned out in this pilot plant include solid round bars 10 in. in diameter, roll sleeves 10 ft. long, 17½ in. outside diameter with 1¾-in. walls, pipe (with bell mouth on one end), 12 in. diameter with 0.57-in. wall thickness.

The summary of properties presented in Table II shows that continuous cast pipe is at least as good as pipe made by other processes. Some of the major utility companies in Germany have laid experimental water and gas service lines utilizing 3-m. (9.84-ft.) lengths of continuous cast pipe and they have proved their worth beyond a doubt. These include 15¾-in. pipe in water mains laid in 1952 in Dortmund, in 1953 in Gelsenkirchen and in 1953 in Hamburg (in both water and gas systems). Hamburg also installed some water pipe of 31 in. diameter in 1955.

Application to Commercial Products

A re-evaluation of possible fields of application indicated that the usefulness of continuous cast shapes was not as narrow as originally assumed. Besides rods of varying diameter, cast iron roll sleeves for rolling mills offered especial advantages. After the establishment of optimum casting conditions hollow tubes were cast 10 ft. long and about 17½ in. outside diameter and wall thickness of 1¾ in. Compared to centrifugally cast roll sleeves, the continuous cast sleeves were of vastly superior surface quality, requiring much less machining, especially on the inside diameter.

Billets about 9 in. in diameter and 8½ ft. long for centrifugal casting molds had previously been cast either in sand or permanent molds. Initial trials showed that we could without difficulty and with great economic success make these billets by the continuous casting process. Microscopic examination revealed, as was expected, a considerably denser matrix with a more uniform and more finely distributed randomly oriented graphite network than could be achieved by sand casting. Chemical analyses are quite similar but hardness (Brinell 180) and tensile strength (25,500 psi.) of the continuous cast round are measurably superior to the sand cast (170 and 23,500 respectively). Microstructures at same modification of conventional and continuously cast molds are shown in Fig. 2.

This last example illustrates that special circumstances may suggest the use of the continuous casting process even if, at first sight, the intended application seems to exceed its practical possibilities. For instance, marine diesel engines, depending on their size, need up to eight cylinder liners for piston diameters up to 30 in. An alloy cast iron is used, but the production of sound liners, sand cast or centrifugally cast and free from surface imperfections, is difficult in such a large tube. The problem therefore was to continuous cast cylindrical hollow shapes, weighing about 6 tons and meas-

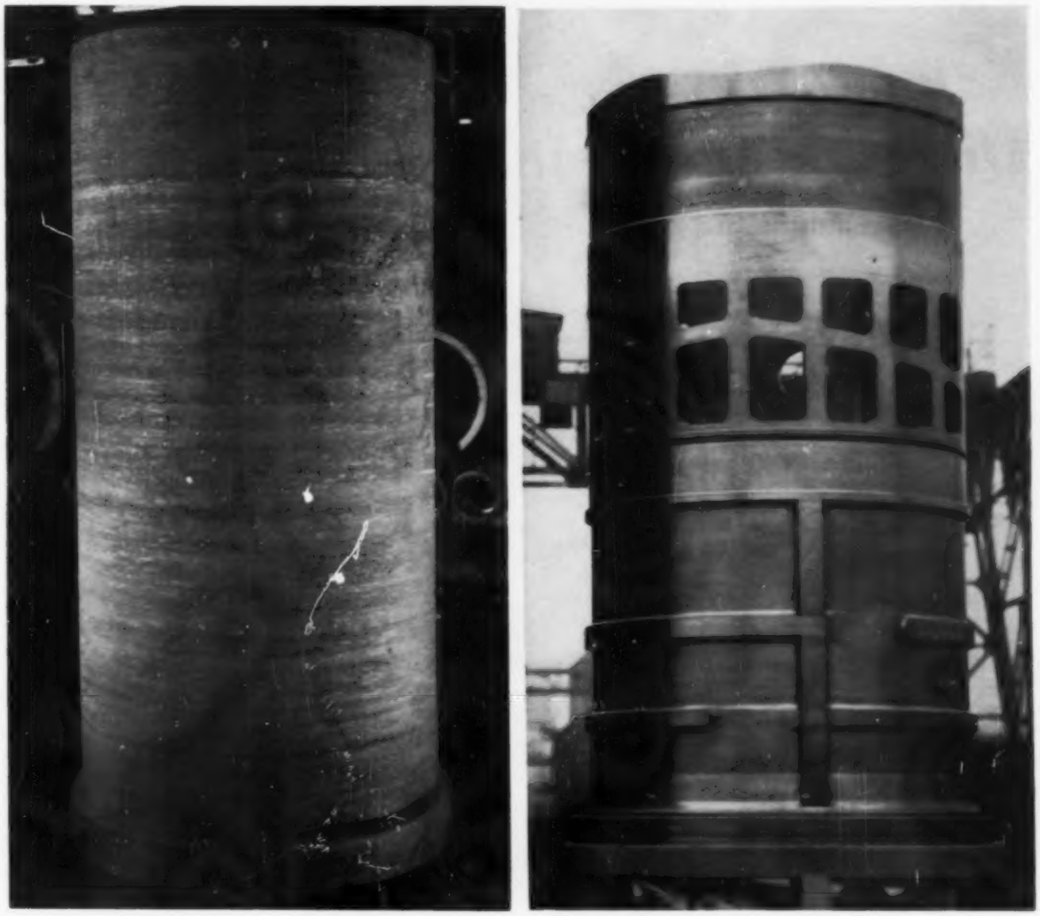


Fig. 4 – Marine Diesel Cylinder Liner, as Cast and After Machining. Approximate dimensions of casting are 40 in. outside diameter, 3⅜ in. wall, 7 ft. long, weight 7700 lb.

uring 40 in. outside diameter, 7 ft. long, with a wall thickness of 4¾ in. After machining, the inner surfaces must be flawless. Figure 3 shows the casting as it is being made. Note that the slowly descending platform carries a dummy or false bottom which supports and slowly withdraws the tubular casting as it is being cast from a hidden ladle on the upper floor. Figure 4 illustrates the cylinder liner as cast and after machining. As shown, the latest liners have been made with integrally cast flange, which reduced the weight as cast to less than 4 tons and the wall thickness to 3⅜ in. More than 100 of these liners have been delivered and installed to date. Performance and resistance to wear are excellent.

Based on results obtained during the operation of the pilot plant, the production unit shown at the head of this article was planned early in 1953. At the beginning of 1956 this plant was officially dedicated. Pipe up to 1 m. in diameter and 10 m. long (3⅓ ft. in diameter and 33⅓ ft. long) could then be cast for the first time. Cast iron pressure pipe for gas and water lines of this size was first shown at the Technical Fair in Hannover and then during the International Foundry Congress in Dusseldorf. They constitute the longest pieces of cast iron pipe ever made commercially.

The full value of the continuous casting of gray iron cannot yet be estimated. However, it is reasonable to predict that, within a very few years, this new process will be established in those progressive iron foundries which make a sizable tonnage of product of suitable configuration and design.

Review of Die Casting Practices Abroad

By *DONALD L. COLWELL**

Aluminum die castings are made in proportionately higher tonnage than zinc; in both kinds the chemical specifications are tighter than in America. Aluminum castings with silicon-free surfaces, capable of anodizing and coloring, are sought on both sides of the ocean. (E13; Al, Zn)

THE TERM "die casting" in Europe may refer either to "gravity die casting" or to "pressure die casting". The former is commonly called "permanent mold casting" in the United States and the latter is commonly referred to as "die casting". This review will consider only what the American would call "die casting" or the European "pressure die casting".

Tonnage

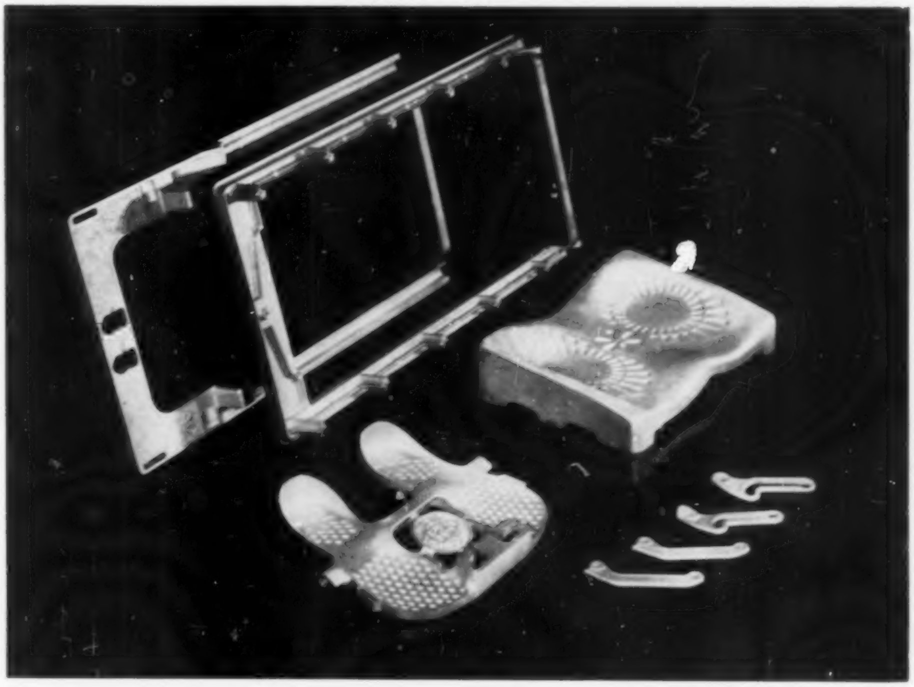
With the great production – mass production – in the United States, the die-casting process has reached its peak because its greatest value occurs when the quantities required of a single piece are large. If all of Europe could be considered as one nation, eliminating trade barriers such as import and export duties, currency restrictions, export licenses and a varying rate of exchange, the freer circulation of manufactured goods would provide a tremendous stimulant to the European die-casting industry. As it is, the 1956 production of zinc die castings in Europe was about 75,000 metric tons compared to 320,000 metric tons in the United States; in the same year about 60,000 metric tons of aluminum die castings were made compared to 168,000 metric tons in the United States.

It is natural, therefore, that the technical practices in the United States should be somewhat in advance of the rest of the world. This matter is apparent when considering the report of Tecaid Mission No. 155 (a group of Europeans which toured America), published by the Organization for European Economic Cooperation (Paris) in 1955. This was a keen evaluation by non-American die casters of typical American practices. Another revealing document is the *Proceedings* of the Second International Conference of the European Pressure Die Casting Committee held in Paris in May 1957, which presented not only reviews of American practice but some stimulating thoughts on several European developments. This committee has even collected a dictionary of die-casting terms in five languages – English, French, German, Italian and Spanish; it is obtainable from the Zinc Development Association, 34 Berkeley Square, London, W. 1, England.

Machines

Some attention is being given in Europe to the matter of pressure – that is, the reputed superior properties of zinc-base die castings from the plunger machine in comparison with those from the air machine. In this respect they are catching up to U.S. practice. Quantitatively, density and strength are increased somewhat by the greater pressure, other factors being equal. The plunger type of die-casting machine for aluminum was developed in Europe prior to World War II, originally with a vertical plunger. This is still the plunger machine commonly used outside the United States. It has some advantages over our horizontal machines and also some disadvantages, the latter largely due to the limi-

*Vice-President, Apex Smelting Co., Cleveland.



tations on size and pressure. Die casting of magnesium and its alloys is generally more prevalent in Europe than in the United States, and the use of the gooseneck machine for magnesium castings was rather widespread in Germany during the War. The "Dow Metered Metal Machine" is an improvement of the same principle.

The use of nodular iron for goosenecks, plungers and other machine parts in contact with molten metal is a matter which should be given greater attention here. Induction melting furnaces, particularly for aluminum, using ordinary line frequency are entirely a European development which has not yet been tried in America, as far as the present reviewer can determine.

At the ASM's Second World Metallurgical Congress in Chicago in November 1957 considerable interest was evidenced on the subject of vacuum die casting. American developments in this respect are being closely watched. The general opinion of our foreign visitors was similar to that commonly held here—namely, that some of the claims made for the process will not be borne out in practice.

Die Steels

The most common die steel, particularly for casting aluminum, seems to be the same in Europe as in America—namely a low-carbon steel with 5.0 to 5.5% chromium and 1.0 to 1.5% molybdenum, with or without a little vanadium. There seems to be a greater tendency, however, to use the hot working high speed steels containing 9 to 12% tungsten (these are largely obsolete in the U.S.).

Europeans often harden the dies in salt baths. This method was used by the present writer years ago, but it has been generally abandoned in America. Yet, in the opinion of some of the Europeans, steels hardened in salt baths give superior results.

One of the newer developments in England is the so-called Shaw process of casting toolsteels in a refractory mold made of a colloidal solution of silica in alcohol.* Claims are made that accuracy is equal to a machined die and die life is almost as good. The economics of the process are self-evident if the service is there.

Die Casting Alloys

Zinc-base die casting alloys used abroad are similar to the two American alloys No. 3 and No. 5 with a greater preference shown there, as here, for No. 3. Some uncertainty seems to exist, particularly on the continent and in Japan, over the desirability of the 4% aluminum content—

*See "Low Cost Molds and Dies by Casting", *Precision Metal Molding*, March 1956.

Table I – Principal Aluminum Die-Casting Alloys

	German	British		American	Proposed I.S.O.
Specification	DIN 1725	BS 1490:1955		B85-56T	
Symbol of alloy	GD-AlSi8(Cu)	LM-2	LM-24	SC84A	Si8Cu3
Copper	0.4	0.7 to 2.5	3.0 to 4.0	3.0 to 4.0	2.5 to 4.5
Iron	1.0 *(a)*	1.0	1.3	1.3	1.3
Magnesium	0.5	0.30	0.1	0.10	0.15
Manganese	0.5 *(a)*	0.5	0.5	0.50	0.6
Silicon	6.0 to 10.0	9.0 to 11.5	7.5 to 9.5	7.5 to 9.5	7.0 to 9.5
Zinc	0.4	1.2	1.0	1.0	1.2

(a) If iron is more than 0.4%, manganese should be more than 0.25%.

although that amount has been very well established here by the experiments of the New Jersey Zinc Co. and the development by the Bunker Hill Co. of 99.999% zinc.

On the other hand, some European specifications are considerably tighter than ours, the British generally specifying a maximum lead content of 0.003% and a maximum tin content of 0.001%. The French use a similar specification; their highest limits are 0.005% lead and 0.002% tin (compared to our 0.007% and 0.005%). Some experimental work on the effect of nickel seems to indicate a safe maximum of 0.01% whereas the American Society for Testing Materials specification allows 0.02%.

A German study of zinc-base die-casting alloys made from 99.999+% zinc also shows its improved properties. This is a matter which should be particularly interesting to Americans because zinc of about this purity is now commercially available.

It might also be worth while examining the rather comprehensive Japanese report published six years ago on the properties of various zinc-base alloy combinations with aluminum, and the effects of copper, magnesium and iron.*

Aluminum—There also seems to be a greater tendency to use aluminum (or magnesium) die castings rather than zinc die castings in European automobile parts. The principal aluminum die-casting alloys are shown in Table I, and the greater emphasis on silicon as a strengthener rather than copper is evident. The British LM24 is a recent addition to this list and has the same composition as the American SC84A. Its influence is also shown in the specification proposed by the International Standards Organization (I.S.O.). In general, permissible ranges of alloying elements in foreign specifications are greater, giving less uniformity in the product. However, the German requirement for controlled amounts of manganese and iron should result in a distinct improvement and could well be practiced in America.

Finishing

A suitable production alloy for aluminum die castings which can be anodized in light colors seems to be as desirable overseas as here. Again the answer seems to lie more toward the use of silicon-free alloys which are more difficult to cast. One process for removing the silicon from the surface, leaving behind a pure aluminum suitable for anodizing, has been patented but apparently has not yet been put to commercial use.

The British Nonferrous Metals Research Assoc. is working on several projects for finishing zinc die castings, as well as the testing of a chromium plate by SO_2 rather than by the salt spray or humidity cabinet. The Association also has in the Patent Office claims for a two-stage process for conversion coatings; although details are not available, it is said to have an acceptable appearance and good corrosion resistance.

In Europe it is not at all uncommon to grind or polish a zinc-base die casting prior to chromium plating, whereas the American custom is to produce "hardware" with a smooth enough finish to require buffing only. Grinding or polishing is limited to the parting line or gates. A degreasing process was described at the meeting of the European Pressure Die Casting Committee for cleaning zinc die castings by ultrasonics. This interesting idea seems to have, as its principal drawback, the limiting size of the transducers. Application to rather large castings and a greater number of castings seems practical.

In summation, it may be said that, under the handicap of generally smaller quantity production, European and Japanese practice has taken advantage of American developments. Not only that, but in several respects they have gone further than Americans.

*"Studies on Zinc Base Die Casting", by Masso Kato, Report of Industrial Sciences, University of Tokyo, March 1951.

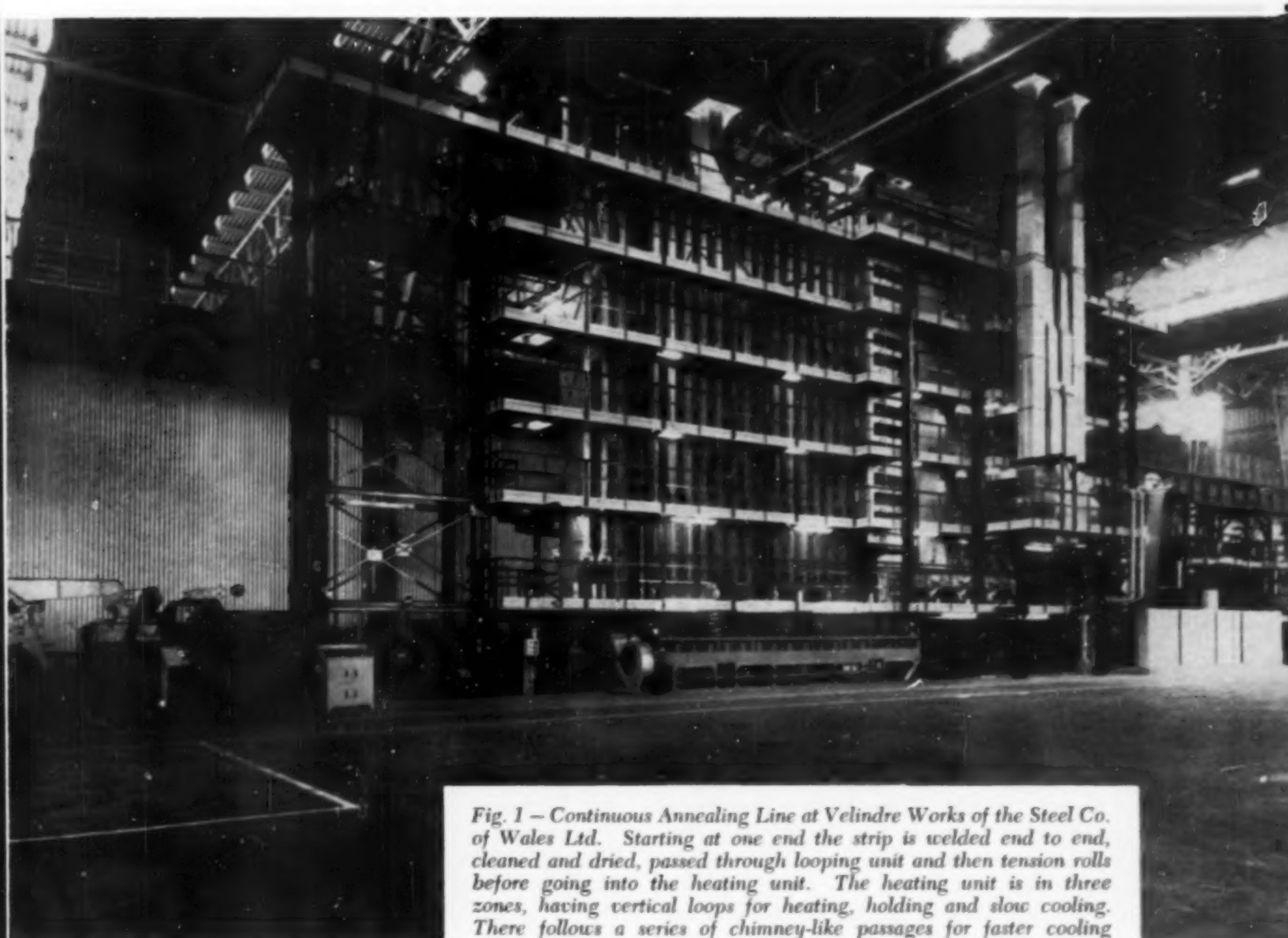


Fig. 1 – Continuous Annealing Line at Velindre Works of the Steel Co. of Wales Ltd. Starting at one end the strip is welded end to end, cleaned and dried, passed through looping unit and then tension rolls before going into the heating unit. The heating unit is in three zones, having vertical loops for heating, holding and slow cooling. There follows a series of chimney-like passages for faster cooling

Some Advances in Tinplate Technology

By W. E. HOARE*

Tighter thickness tolerances, annealing for both stiffness and ductility, improved tinning machinery (both electrolytic and "roller coatings"), electronic control of high-speed lines, new devices for rapid estimation of corrosion resistance. (L17, L16, F23, ST, Sn)

MANUFACTURE of tinplate by what can fairly be described as the modern method started about a quarter of a century ago with the advent of the continuous mill rolling hot strip in large widths (strip sheet). This was followed quickly by the development of fast continuous mills for cold reduction, by the electrolytic process for applying the tin coating and, more recently, by the widespread adoption of continuous strand

*Assistant Director, Tin Research Institute, London, England.

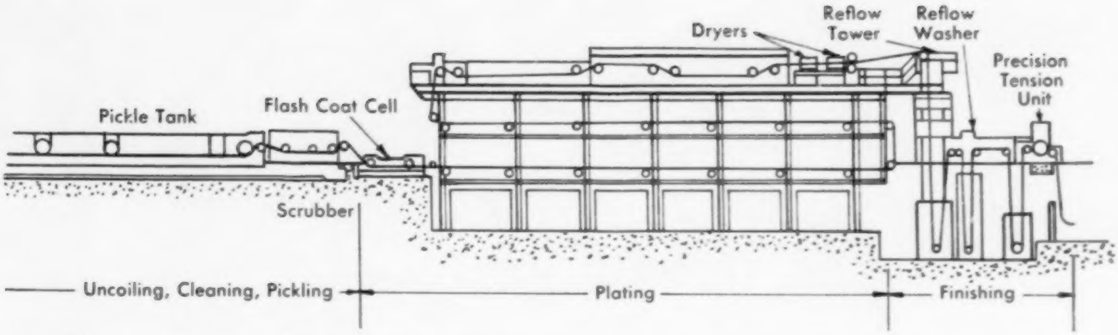


Fig. 2 – "Halogen" Type of Electrolytic Tinplate Line, With Three Horizontal Superimposed Tanks. (Courtesy, Wean Engineering Co.)

annealing of the base steel strip. These major improvements have been accompanied, and indeed made practicable, by a multitude of other advances in the metallurgy, engineering and control of manufacturing operations, and in better understanding of testing for quality control and appraisal.

So wide is the subject that I have thought it best to select for discussion some few aspects of tinplate technology that have a measure of novelty; such treatment may be of more interest than a mere serial account of the manufacturing process. None the less, a broad view of the process is helpful, and the normal manufacturing sequence will be given briefly.

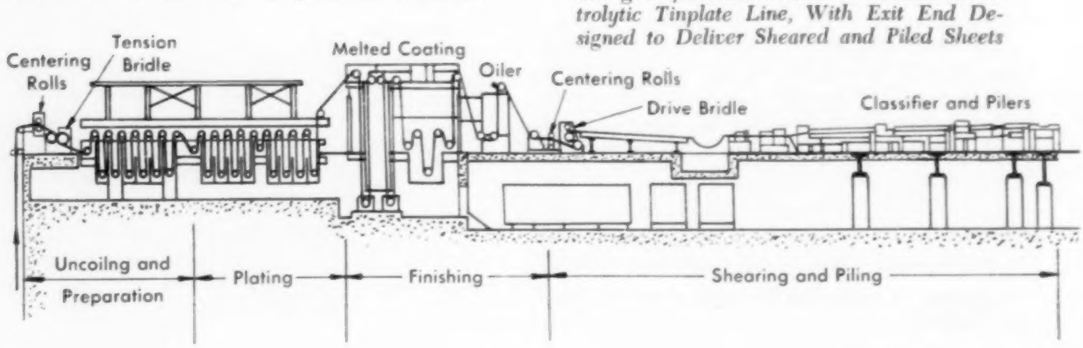
The Hot Rolled Band – Taking the world as a whole, most tinplate steel is made by the openhearth process, although in continental Europe the use of oxygen-blown bessemer steel is now widespread. As far as possible (and certainly for tinplate for the more critical services) pure grades of rimmed or capped steels are used, residuals being kept to the practical minimum. Some rephosphorized steels are used where relatively great stiffness is required in the finished product – for example, for very large cans and for the ends of pressure containers.

In the light of much study of the effects of residuals and metalloids on the corrosion behavior of tinplate steel, it is perhaps curious that the only element added intentionally is phosphorus. Other additions, known to increase corrosion resistance in certain fields of use, have been proposed from time to time, but nowadays the best over-all answer is known to be the use of pure steels with no intentional alloy additions and with good control of metallographic structure by proper attention to hot mill practice.

Cold Reduction – After pickling, usually in hot sulphuric acid but occasionally in warm hydrochloric acid, the hot rolled strip is oiled and passed on to cold reduction. In this operation the gage is normally reduced in four to six mill passes from about 0.1 in. to about 0.01 in. Cold reduction is always done under intense lubrication with palm oil or its emulsions, despite attempts to find substitutes.

Almost all the larger producers use the five-stand tandem mill with delivery speeds upwards of 5000 ft. per min. Modern mills of this type produce fantastic amounts of very highly finished material; weekly tonnages approaching 10,000 long tons are not uncommon. Medium and small producers often favor single-stand

Fig. 3 – Schematic Diagram to Same Scale as Fig. 2 of Vertical Acid or "Ferrostan" Electrolytic Tinplate Line, With Exit End Designed to Deliver Sheared and Piled Sheets



reversing mills with tension reels on both sides; their advantages are output flexibility and lower first cost.

Although the average gage of tinplate base may be taken as around 0.01 in., rolling to 0.008 in. and in widths up to 36 in. is not uncommon. Such practice exemplifies the basic problem of producing tinplate base – that is, the production of very light-gage highly finished material in wide widths at high speed. The resulting procedures place increasing emphasis on automation in the cold reduction mill.

Automation gage control in strip mills has become of outstanding importance, not only due to the steady increase of delivery speeds, but also because customers are constantly asking for tighter gage tolerances. Whether it arises from gage variations in the hot rolled band, from mill accelerations and slow downs, or from loosely controlled mill practice, the production of off-gage must be kept at a minimum. In practice this means that the proportion of time during which the mill is producing off-gage material must be kept to an absolute minimum.

Whatever technique of control may be used, sound instrumentation of the mill is necessary. Strip thickness must be metered at exit (and possibly elsewhere as well). Screw-down loads and inter-stand tensions must be measured. A picture or record of any inherent gage variation in the hot rolled band, as received, is a further advantage. Linking together of all such information is a matter of electronics engineering now almost deserving the adjective "classical," but its proper use to correct variation of gage immediately (or even before it occurs) is, however, not only a problem of designing fast servocontrols but also of a deeper understanding of just how a fast tandem mill is affected, both mechanically and electrically, by intentional or unintentional variations of true load. Automatic gage control is rather in its infancy but its parents believe it has remarkable promise for higher productivity and better quality.

Annealing – After removing the lubricants in continuous electrolytic cleaning lines, the cold reduced strip passes to the annealing stage. There is no doubt that the outstanding advance in annealing practice in recent years has been high-speed continuous strand annealing furnaces.* Although strand annealing has been practiced at two famous plants for many years, the bulk of tinplate stock has normally been box annealed in coils in batch furnaces. In reality, such box annealing provides a "process anneal" involving relatively slow heating to a temperature near the lower critical point, soaking, and then cooling to where the coil can be safely exposed to air and handled. The process has well-known virtues and high unit capacity, a single furnace cover holding about 250 tons of stock. Despite shortening of the cycle by such means as atmosphere circulation during heating and forced draft cooling, the procedure remains a lengthy static operation in a line-up that is now otherwise almost completely continuous. Moreover, with increasing coil diameters it becomes more and more difficult to insure a reasonably uniform heat treatment throughout the coil and the furnace load. The target of continuous operation is always a worth-while one, and this target tangibly presented itself as soon as tinplate base became available in strip as distinct from sheet form. In the last five years development has been so rapid that a very considerable tonnage of tinplate is now annealed by the continuous method.

The fastest plants have been installed in the United States and similar ones are in operation or in building in Europe (Fig. 1). Such plants will operate at speeds from 500 to above 1000 ft. per min. and the general sequence of operations is indicated in the caption. Despite the fact that the over-all length of the strip is probably about half a mile, it will be seen that the actual heat treatment operation itself is of extremely short duration – 2 min. at most. Morever, the strip receives a significant amount of stress by tension and bending about upper and lower sheaves while it is hot. The effects of this sort of treatment have received a good deal of fundamental study and some of the results are metallurgically very interesting.

The advent of continuous annealing has placed in the hands of the tinplate manufacturer and user a material with rather unexpectedly unique properties. Sometimes it combines with apparent fortuity the two desired properties of stiffness and ductility. This has given rise to the description "TU" for it, meant to indicate that continuously annealed strip can, in certain fields and with proper care and appreciation of its qualities, be used for a wider range of uses than box annealed material.

Continuous annealing can and is also being done in horizontal furnaces. An excellent example is at the Andernach plant of the Stahl und

*See also the report of the recent conference, "Annealing of Steel Sheet", published in *Metal Progress*, December 1957, p. 110.

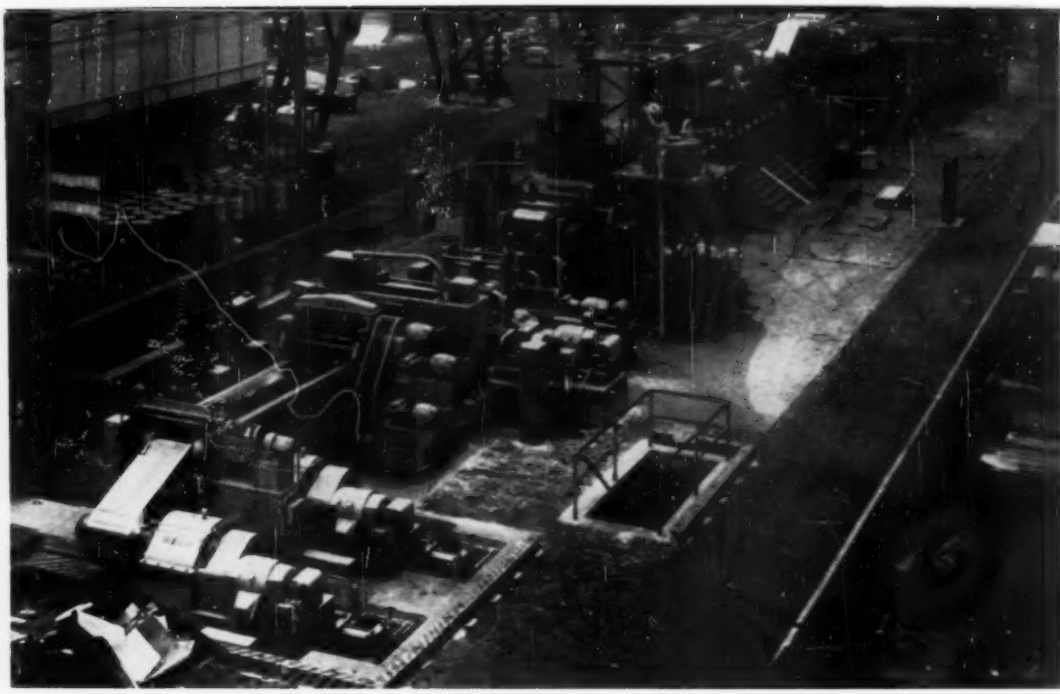


Fig. 4 – High-Speed Electrolytic Line at the Ebange Works of Sollac, Ltd., France

Walzwerke Rasselstein at Neuwied, near Koblenz, West Germany. One long building houses two "three-decker" furnaces, each of which is in effect three furnaces, one on top of another. They handle strip up to 1 m. wide (40 in.), 0.2 to 0.5 mm. thick (0.0008 to 0.020 in.). One furnace runs at 215 ft. per min. and treats about 4000 long tons per month. The other is somewhat faster (260 ft. per min.) and produces about 5000 tons per month. Heat consumed is about 215 Btu. per lb. of product. They are economical producers of very high-quality material.

A further change in annealing practice in recent years is the use of particular protective atmospheres. These furnace atmospheres are designated "NX" and "HNX" and are essentially mixtures of nitrogen and hydrogen. They help produce those surface characteristics in the steel which promote high corrosion resistance in the finished product.

Tinning

After annealing, either continuously or in batch furnaces, the coils are usually run through a two-stand, four-high temper mill and the edges trimmed. If the steel is to be tinned as sheet, the coils are cut up and stacked; otherwise the coils are sent directly to the electrolytic line.

Electrolytic tinning lines have reached an advanced stage. Sometimes speeds above 2000 ft. per min. are provided for, and production capacity of a single plant is commonly above 100,000 tons per year. Installations which shear the finished strip to sheet lengths in line are limited by the speed of the flying shear, but even then, speeds approach 1000 ft. per min. Newer and revamped lines often have extra plating tanks and higher direct current power to lay on heavier coatings at high speeds. The development of differentially coated tinplate, which usually carries 60 micro-inches of tin on one face but only 15 micro-inches on the other, has stimulated the use of such higher plating capacities.

Figures 2 and 3, schematically at same scale, show two successful types of electrolytic tin lines. The fastest lines now operating are those of the horizontal "three-decker" type (Fig. 2), but in Europe the vertical serpentine line, usually known as the Ferrostan type (Fig. 3 and 4) has generally been favored. In addition, a number of smaller but very efficient units, working at speeds around 75 to 325 ft. per min. are now operating in Germany.

Much attention also has recently been given to the finishing operations, namely, filming and oiling. Fruitful investigations have given better knowledge of the composition and characteristics of artificially formed passivation films by the various chemical and electrochemical methods. This work is leading to "tailor-made" surfaces for special purposes. Just now, studies are in progress on surface oils and oiling treatments with a view to providing films of better uni-

formity and improved compatibility with the organic finishes widely applied to tin plate.

Improvements in the time-honored hot dip tinning process have been a little overshadowed by the very rapid changeover to the electrolytic method, but the older process continues to yield an economic and sought-after product. Although little new attention has been given to the process in the United States, this has not been true elsewhere. Much new plant of impressively up-to-date design has been installed in Europe in recent years, either the Melingriffith tinning machine or Poole-Davies tinners with automatic sorting, a good example being shown in Fig. 5. Modern plants, comprising a complete line-up from dry plate feeder to the finished, counted and piled tinplate, are much better engineered than formerly, and tighter operating control is imposed at all points. The theory and practice of the actual tinning operation itself, particularly the action of grease pot rollers and brushes, is becoming better understood, resulting in a much more uniform coating.

The concept of continuous strand hot dip tinning has been given a good deal of study. A considerable amount of continuously hot dipped tinplate in widths often as great as 40 in. is currently being produced in Germany and recent investigations have sought to increase the speed of such units. Investigations in the United Kingdom have resulted in a so-called "roller-coating" process in which the coating is "printed" onto the steel strip by tinned rollers operating in a controlled active atmosphere. This process has shown itself capable of producing coatings of the required commercial range of thicknesses at good operating speeds. A pilot plant for 12-in. strip is shown in Fig. 6.

Quality Appraisal

Modern manufacturing methods enable tinplate to be produced in grades very closely matched to their required duty. This has meant that the rather cursory tests of the earlier years have had to give way to well-planned schemes for comprehensive examination of all mechanical and physicochemical properties. Such tests are both for process control and for quality appraisal; the most interesting developments have been in tests applied to the surface of the material.

Coating thickness is now estimated by rapid chemical methods, by X-ray fluorescence techniques, and by the "coulometric" method. This latter, which determines thickness by measuring the quantity of electricity required to dissolve

Fig. 5 – Nine Poole-Davies Hot Dip Tinning Machines at the Trostre Plant of the Steel Co. of Wales Ltd., All Equipped With Sorting, Classifying, Piling and Counting Equipment

the coating, has the advantage that an additional figure can be given for the tin present as tin-iron alloy. Control of the electrolytic line is by instruments which integrate the operating variables affecting coating thickness – namely speed, current density, width, and efficiency. This provides a constant check on performance. The use of continuously indicating X-ray and B-ray gages for line operation is also becoming more common.

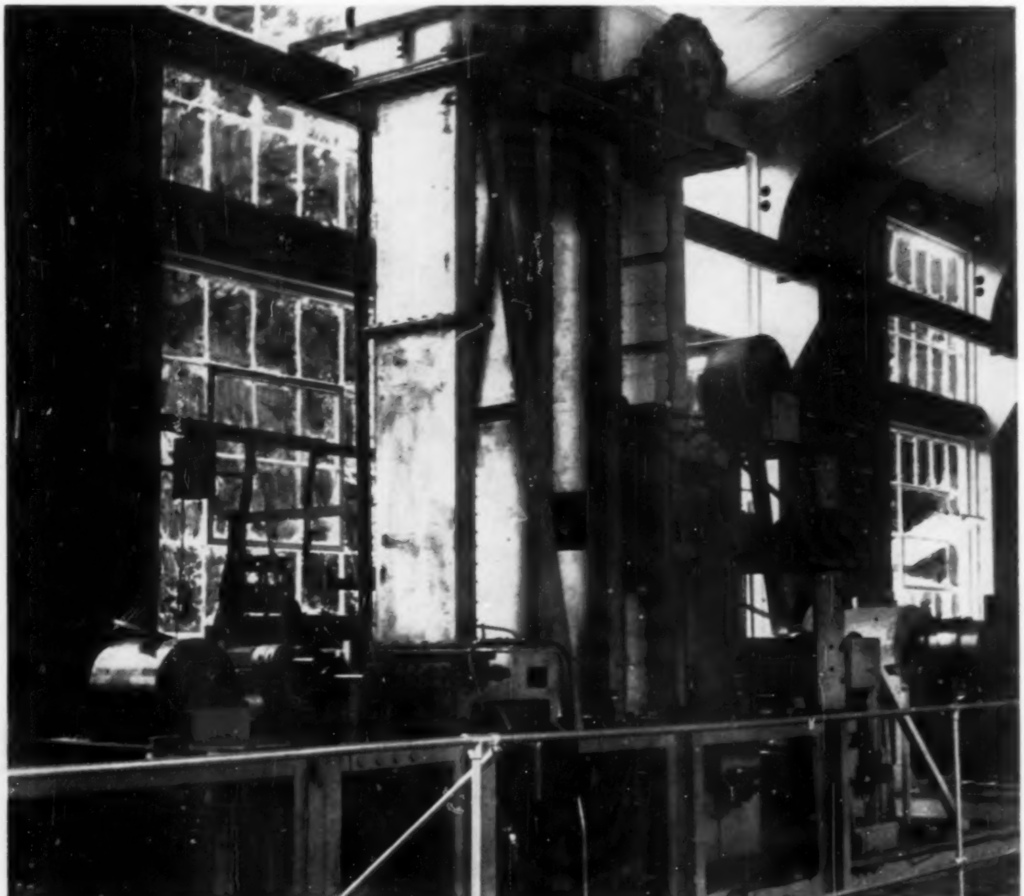
Measurement of oxide film thickness, the importance of which was mentioned above, is usually made by coulometric estimation of reducible-oxygen content. Oil film thickness is estimated by a number of direct and indirect means – for example, solvent extraction and weighing, colorimetric procedures, and the use of the Langmuir hydrophilic balance.

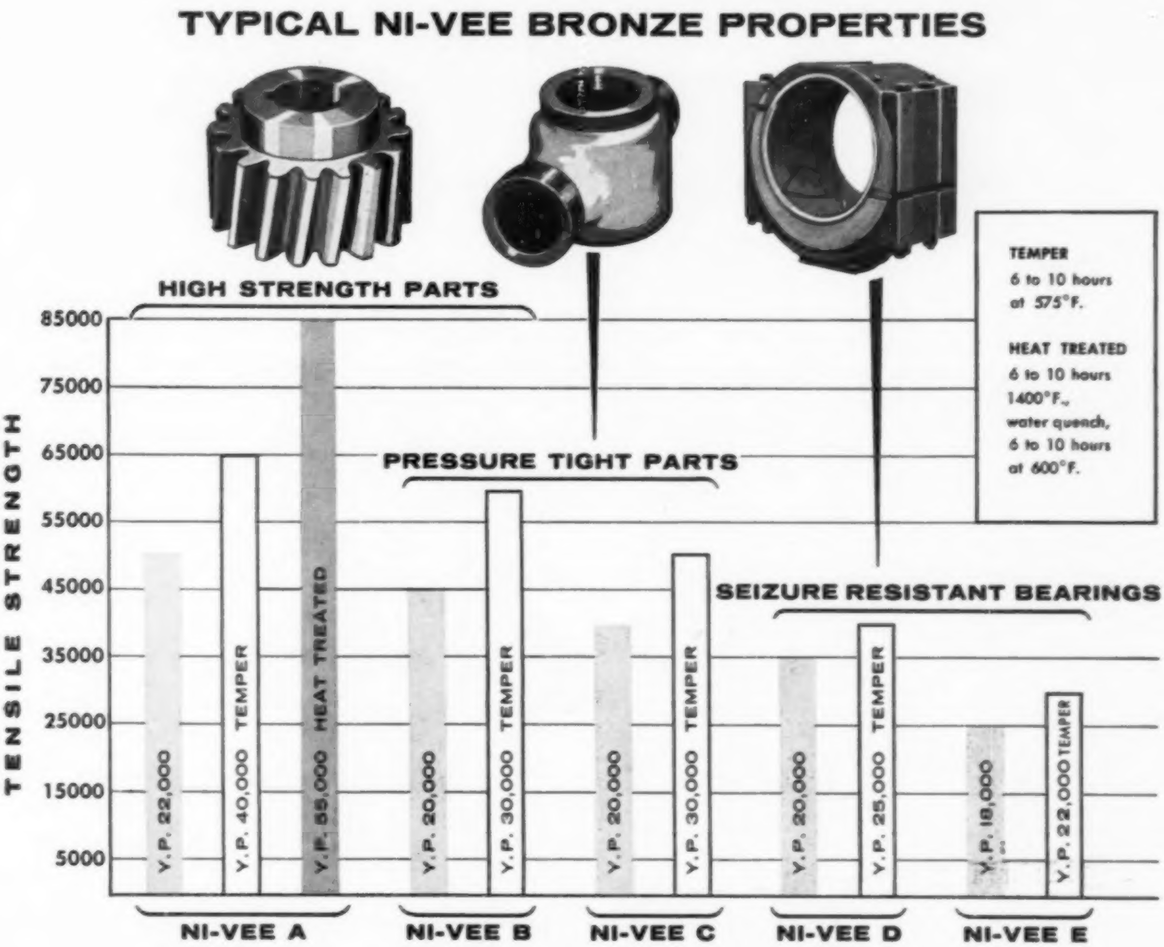
Corrosion tests are most widely utilized in laboratory research, but as new procedures are developed and the significance and usefulness of corrosion tests become better understood, they are coming into use for routine appraisal of quality. Examples are the iron solution and pickle-lag tests which measure rates of corrosion on the steel surface, and the sulphur dioxide rust resistance test designed to estimate the resistance of the tinplate to corrosion by condensed moisture.

It may be said, generally, that good progress has been made in very recent years toward testing procedures which give a more satisfactory correlation with actual performance, but much still remains to be done and fundamental corrosion research (the discussion of which is outside the scope of this article) continues to be active.

The Future – A great deal is expected of tinplate. Who can say how many different products were packed in the fifty thousand million cans made last year, what journeys they traveled, or what variety of conditions they endured? These humble receptacles succeeded in the task of protecting their contents on their way to the consumer. The industry has done well in meeting the expectations and demands made upon it and can claim a good record, both of industrial expansion and technological development. Research, in which the industry has become keenly interested, points the way to further gains in productivity, quality, and consumption.

Fig. 6 – Roller Coating of Tin on 12-In. Steel Strip in Pilot Plant at Swansea Laboratories of British Iron and Steel Research Assoc. (B.I.S.R.A.). The tinning box is just below the large pulley at middle right





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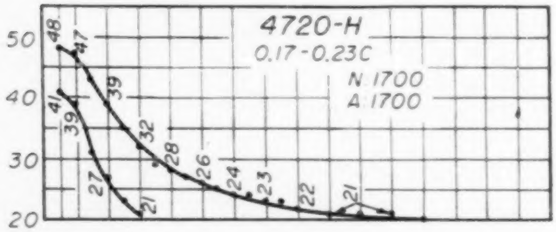
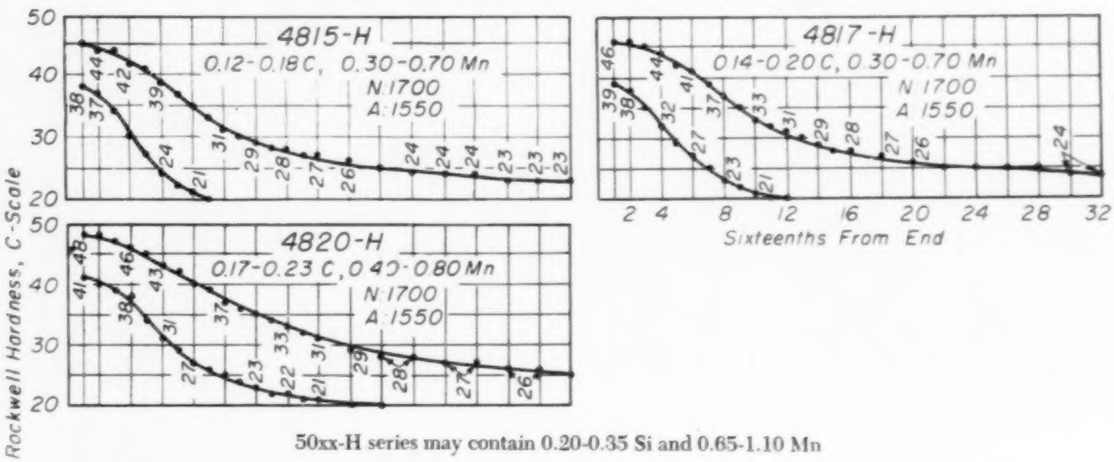
A.I.S.I. List of March 1957

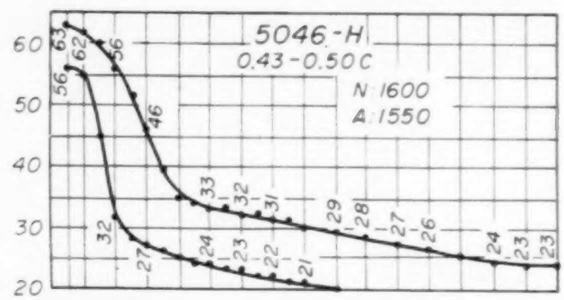
4720-H may contain 0.20-0.35 Si, 0.45-0.75 Mn, 0.85-1.25 Ni, 0.30-0.60 Cr, 0.15-0.25 Mo



48xx-H series may contain 0.20-0.35 Si, 3.20-3.80 Ni, and 0.20-0.30 Mo

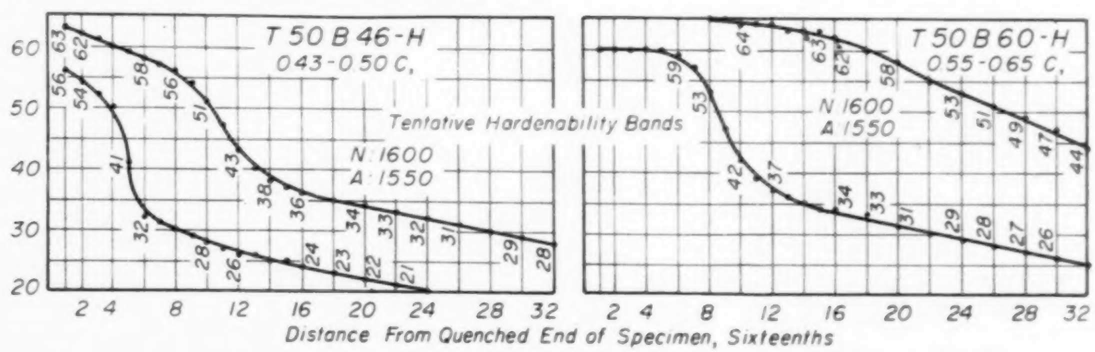


50xx-H series may contain 0.20-0.35 Si and 0.65-1.10 Mn



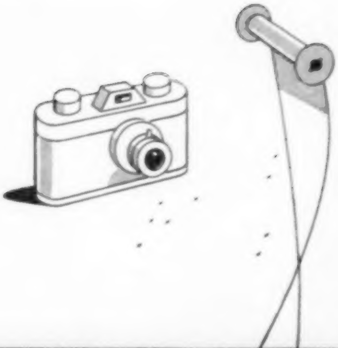
5046-H and T 50 B 46-H contain 0.13-0.43 Cr
T 50 B 60-H contains 0.30 to 0.70 Cr

The boron or B-steels can be expected to have 0.0005 min. B



N means normalizing temperature for forged or rolled material; A means austenitizing temperature (both as recommended by S.A.E.).

Hardness limits are specified in Rockwell C-scale units (no fractions) and can be scaled from the plotted points where not labeled at even sixteenths.



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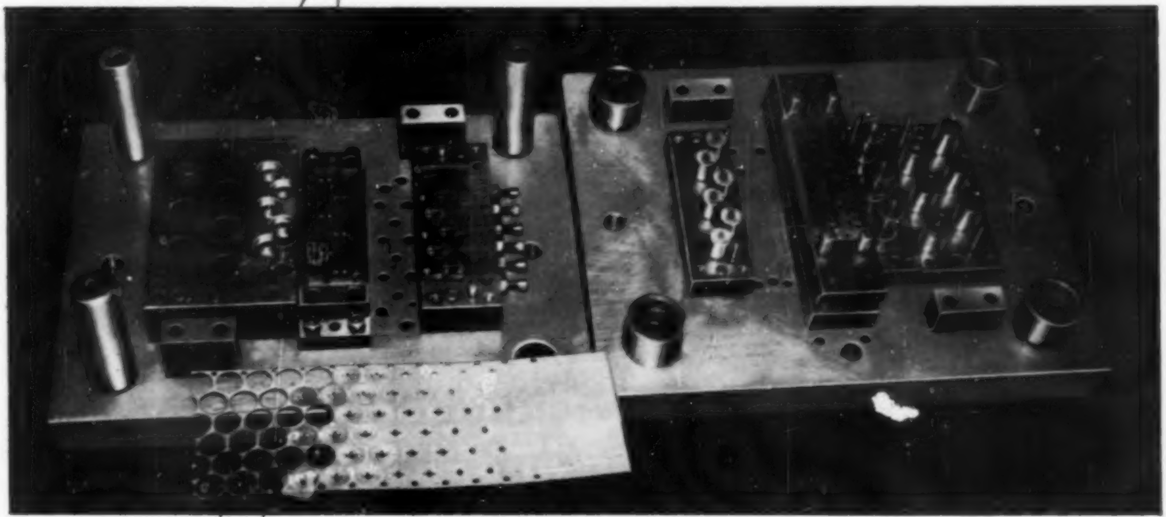

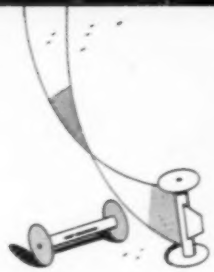

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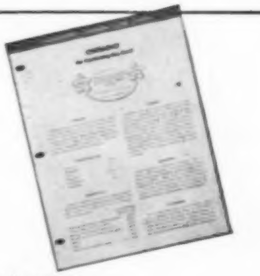

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Recent European Advances in Optical Metallography

*By ROLAND MITSCHE**

Modern microscopes are designed to avoid fatigue of the operator, with automatic timing, continuous focusing, and multiple light sources. Attachments exist for hardness tests and visual observations, in vacuum or controlled atmospheres, at temperatures from −325 to +2700° F. (M20, M21, M23, 1-53)

Even the limited topic assigned by the Editor can be handled only sketchily in the available space. At least three important symposiums have been held within the past 30 months, each of which has resulted in a sizable volume. The brief survey to be given here will say very little about electron microscopy and unorthodox techniques.

Instruments – For fundamental physical reasons no further improvements in resolving power of microscopes have been possible since the classical work of Francis Lucas (who introduced ultraviolet light into metallographic research). Many advances have been made in Europe in facilities and accessories. This will be described in terms of the metallurgical microscope which the author has used for many years, and which is shown in Fig. 1.

First should be mentioned the arrangement of the different parts which enable the metallographer to do his work without bodily overstrain, even if he sits the whole day at the instrument. One small but important detail is the two wooden boxes with inclined tops of foam rubber on which the elbows can rest, thus keeping the body in a biologically correct position. Besides all other normal optical attachments, including dark-field illumination, incident polarized light and continually changing magnification, the following special features may be mentioned:

1. A two-lamp unit for quickly changing a conventional low-voltage lamp to a mercury vapor lamp for highest light density.

2. Equipment for phase contrast of incident light shown at the right of Fig. 1. Change from normal illumination to positive or negative phase contrast is done in the very simplest manner,

*Head of the Department of Metallurgy and Materials Testing, Montanistische Hochschule (Austrian University of Mining and Metallurgy), Leoben, Steirmark, Austria.

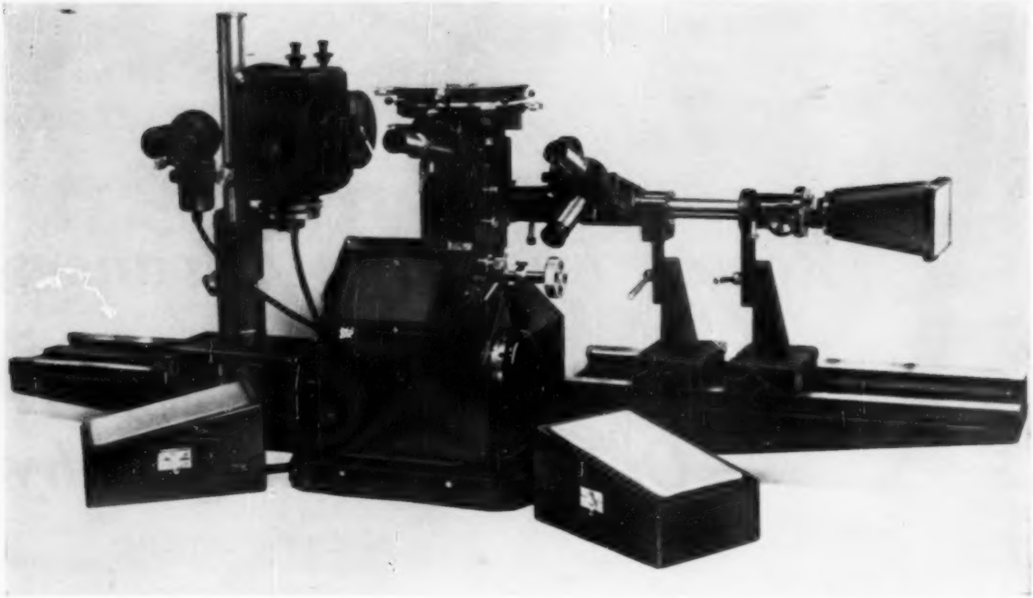
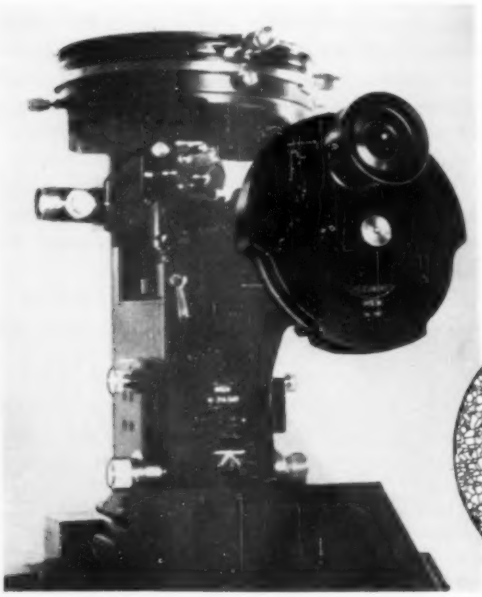


Fig. 1 – Latest Type of European Metallurgical Microscope, Built by C. Reichert of Vienna

merely by pulling a lever which puts the eyepiece tube out of action.

3. A magnetic specimen holder which combines the advantages of Le Chatelier's normal metallographic inverted stage with the upright. The specimen with its polished surface can be moved freely in all directions without any danger of being scratched or damaged in some other manner.



4. An eyepiece and magazine of diagrams representing standard grain sizes and structures (Fig. 2). The tedious work of estimating grain size, checking slag inclusions, measuring graphite, is reduced to a minimum by *direct* comparison of the specimen with a screen covering a part of the field. Turnable screens or magazines are available giving the A.S.T.M. grain size charts, Swedish Jernkontoret's grain size diagrams, the graphite charts of the American Foundrymen's Society, and so on.

5. It is often necessary to show a clear, bright microscopic picture to several people at once. For this purpose an accessory known as the "Didactoscope" has been developed in which

Fig. 2 – Eyepiece and Magazine for Grain Size, Inclusion, or Structural Standards. Sample fields are for grain size and graphite type

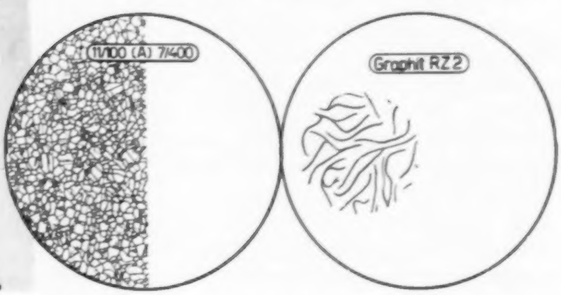
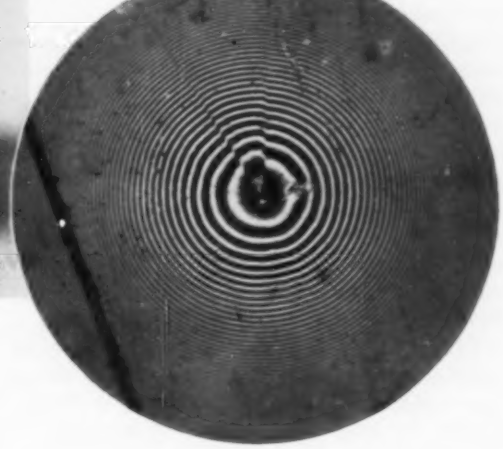


Fig. 3 – Interference Objective Interchangeable With Ocular in Fig. 1. Interference rings show a wedge-shaped step growing on a single crystal of cadmium. 200×



the picture up to the highest magnification appears on a 10-in. glass screen on the front of a tilting box containing a reflecting mirror. Up to eight observers can see all details simultaneously, and a useful discussion based on the actual microscopic appearance of the specimens can be had.

6. Television is a valuable adjunct on those many occasions when metallographic structures are to be discussed before a large audience. In our University we teach fundamental metallography to classes of from 50 to 80 students. We have solved this problem successfully by photographing the microscopic image by a television camera and transmitting it with a Phillips' portable TV transmitter to several receivers, according to the number of the students. Even without color, television yields gratifying results. We hope that, in a not too distant future, we will be able to add this extra refinement of color pictures.

7. An interference tester is an accessory shown in Fig. 3. It consists of a special objective fitted with a test glass in front of the objective. The surface of the test glass is either flat (for testing convex samples) or convex (for testing plane surfaces). The test glass is brought in contact with the surface to be tested and the well-known Newton interference pattern appears. Figure 3 also shows a pattern made by a wedge-shaped step growing on the surface of a single crystal of cadmium.

The interference tester is useful not only to scientific research but has proved excellent in such routine work as the inspection of ball-bearing balls.

8. Heating Devices. There is a general interest in the microhardness of metals and alloys below and above room temperature. Likewise direct visual observation of transformations, phase changes and the like is of fundamental interest. For this purpose a rather simple device has been developed, whose detailed description must be omitted due to space limitations. With its aid we have determined microhardness up to 400° C. (750° F) without damage to the tester. We have also made very interesting films of the austenite-martensite transformation at liquid air temperature.

9. Microhardness Tester. The Reichert microhardness tester (which has been used for all our experiments at normal, low and high temperatures) is in widespread use in Europe. Its extremely simple and reliable operation is due to the fact that the objective lens and the indenter diamond are located close together on the movable upper part of the apparatus. Accuracy of less than 1 micron can easily be reached.

The other two leading continental manufacturers of metallurgical microscopes, Ernst Leitz of Wetzlar and Carl Zeiss of Oberkochen, have also contributed greatly to instrumental developments. Only two or three examples can be given here.

Figure 4 gives a general view of the Zeiss "Ultraphot" whose special features (besides optical system of top quality) are built-in light source

and an automatic, pushbutton photographic device, in which the correct exposure is controlled automatically. The magnification scales can also be varied continuously. To meet all demands of illuminating power, three different light sources are available.

Another late device of Leitz is the vacuum heating device shown in Fig. 5, which permits direct observations up to 1050° C. (1900° F.) and magnifications as high as 500. The specimen is heated either in vacuo (down to 10^{-4} mm. Hg) or in any gas atmosphere and is watched through a quartz window in the cover. The author has spent a lot of time in great comfort watching with his remarkable instrument the wonders of phase changes, such as martensite formation and re-austenitizing.

In order to extend the working temperature up to 1500° C. (2700° F.) G. Reinacher of Hanau has modified the Leitz heating device so that he is able to make direct visual observations on refactory metals, for example, in the alloy systems based on ruthenium or iridium.

Polishing and Etching Methods – Light microscopy requires adequate polishing and etching. Progress made in this field in the last few years could perhaps fill a volume of its own. Many advances can only be indicated by one example in the field of electropolishing and etching.

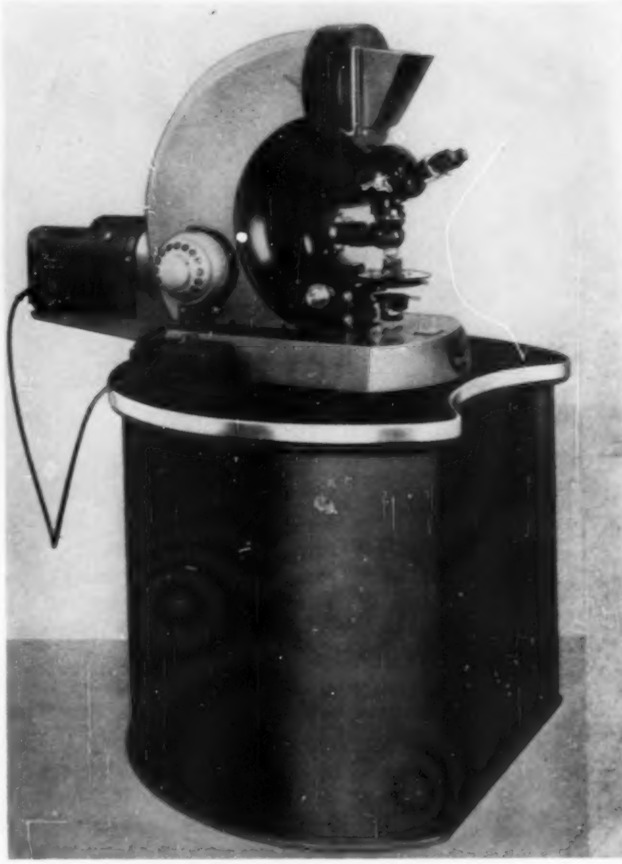
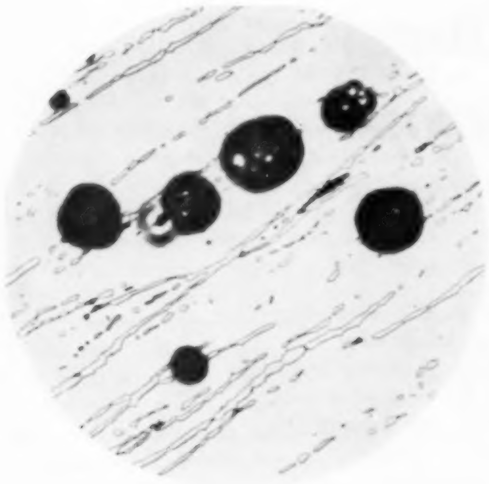


Fig. 4 – Latest Metallograph by Carl Zeiss With Automatic Exposure Timer, Continuously Variable Magnification, and Three Illuminating Sources

Fig. 5 – Device for Heating Metallographic Samples in Vacuum or Controlled Atmospheres. Courtesy Ernst Leitz

E. Knuth-Winterfeldt of Copenhagen, Denmark, has improved his "DISA" electropolishing apparatus as well as devised better electrolytes for specific classes of alloys. For example, Fig. 6 demonstrates one of these forward steps. The specimen is a titanium-stabilized stainless steel. While one view gives the appearance which could be got about two years ago, the other demonstrates the remarkable progress which has been achieved by altering the electrolyte.

Many further improvements have been made in the field of electropolishing and etching. Reinacher's precious metals electropolishing device may be mentioned. Another electropolishing apparatus has been developed primarily for electropolishing uranium by E. C. Sykes and co-workers at Harwell, England; they also developed the use of plastic laps.



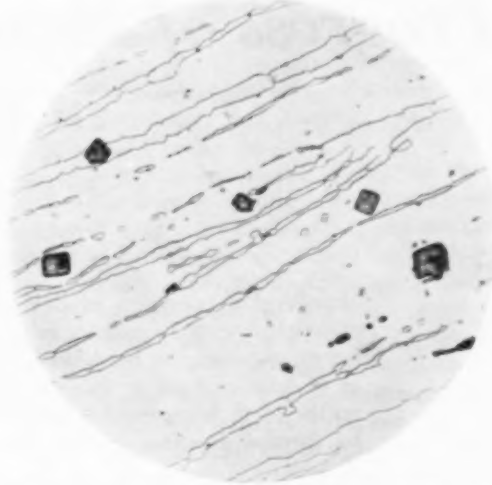


Fig. 6 – Titanium Stabilized 18-8, Electrolytically Etched, in Knuth-Winterfeldt's "DISA" Equipment, Illustrating Improvements in Electrolytes

Electron Microscopy

While the foregoing account deals briefly with devices using the visible spectrum, this brief review should not close without a brief mention of other rapid progress in modern metallography.

Electron metallography has indeed advanced greatly in the last decade. At about that time one of the leading American metallographers expressed the opinion that electron micrographs, using the replica technique, showed little if anything an excellent optical instrument would not reveal. This certainly is no longer true, as can be found immediately by consulting the survey made by the late B. von Borries of Düsseldorf and published in 1956 in a special issue of *Radex Rundschau** and the proceedings of an international meeting in Liège, Belgium, early in May 1956 under the joint auspices of the Engineering Alumni of the University of Liège and the Belgian Center for Metallurgical Research†. The Max Planck Institute for Iron Research in Düsseldorf, Germany, is also publishing continuously valuable investigations in this field.

Once the constructors of electron microscopes outgrew their early attempts to manufacture a glorified optical microscope, and realized that an electron microscope is a scientific instrument in its own right, progress was rapid. At present it may fairly be said that the electron microscope is most useful in that region intermediate between optics and X-ray diffraction patterns.

*Sponsored by the Austrian-American Magnesite Co., Radenthein, Austria, a subsidiary of General Refractories Co., Philadelphia.

†*Revue Universelle des Mines*, 1956, No. 10.

Perfection of microtomes has also allowed the experimenter to prepare sections 100 Angstrom units thick, and the resolution of images from beams transmitted through them is from one-tenth to one-twentieth the thickness. Again new "lens" systems permit direct observation of surfaces by reflected beams.

Work with such new equipment (of which only two examples have been given) has resulted in the discovery of micro-slip which explains the hardening of overstrained metal between visible slip bands. Furthermore these new techniques have been invaluable in the study of oxidation products and other surface phenomena.

Unorthodox methods cover an intriguing and important field of itself. In it may be included the use of radioactive isotopes as markers. Contact prints made from such samples have poor resolution, and usually show only the broad features of a structure. However "magnetic lenses" are being developed to "focus" the charged particles (beta rays) emitted from the tracers, and resolutions of the order of 1 micron have been reported.

A great future exists in the way of residue analysis – particularly in combination with modern microscopy and X-ray diffraction equipment. It is not too much to expect that important facts will be uncovered concerning the early stages of precipitation hardening, temper embrittlement, and other phenomena thought to be associated with ultra-fine particles of secondary phases.

Progress of Metallurgy in Europe

*By HUBERT SUTTON**

Metallurgical education in England is steadily expanding, although free and rapid interchange of information leaves something to be desired. Pressing problems in Europe as in America have to do with brittle behavior of metals, resistance to hot corrosive surroundings, and damage by thermal or stress cycling. (A9, A3)

In a gathering at Carnegie Institute of Technology, it would be appropriate to introduce a brief account of metallurgical progress in Europe – and more especially in Great Britain – with some remarks on metallurgical education.

At the time of my entering my university and for many years afterward a fresh student could not obtain directly a degree in metallurgy but had to start off with one in chemistry or physics. Metallurgy was one of a long list of rather special subjects which the student might, if keen to do so, study in parallel with the rest in one of the years of training for his degree. To me metallurgy looked about the brightest subject on the list – much preferable to gas analysis or food chemistry, to mention only two. These considerations led to the cellar under one of the chemistry laboratories at Manchester University where the late Prof. H. C. H. Carpenter was, with the help of C. A. Edwards and J. H. Andrew, defying the dust and darkness!

Possibly it was the spirit of adventure which prevailed there, permeating the air, that swept me into metallurgy. Soon I was to join the Institute of Metals and to listen to my first teacher of metallurgy addressing the members as their new president and declaring that our membership was more than 900. That today it is about 5000 – though still small compared with your metallurgical societies – perhaps serves to illustrate the great changes that have taken place during my time in Great Britain.

Yet, so far as teaching institutions in the United Kingdom are concerned there is need for expansion of facilities for teaching and study of the science and technology of metallurgy – and indeed steps are being taken in that direction in many places. Oxford has been a center of learning in England since the time when some English students at the University of Paris were either recalled by Henry II or expelled by the Frenchmen and settled in Oxford. In this year of grace 1957 Oxford has set up a department of metallurgy, metallurgy now being regarded there as a subject of some standing. Oxford now has a chair of metallurgy. To many of you who know Dr. Hume-Rothery and his work this is a very gratifying tribute to a very good basic work well done and to the achievements of the group he has gathered at Oxford. Steady expansion is under way elsewhere.

International Contacts – It is impossible to overlook, in considering metallurgy in Europe or anywhere else, the influence of two devastating world wars. You, as well as we, know from experience the terrible loss of life, the wastage of material effort and time.

Despite our modern television I often think that we have lost something in the field of communications since the days of 1813 when Sir Humphrey Davy, with his wife, his maid and his laboratory assistant named Michael Faraday, set out with large boxes containing scientific apparatus to cross the English Channel in a

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small boat they had chartered. At the time England and France were actually at war, but the party had cordial receptions by French scientists and even by Napoleon himself.

In the United Kingdom we have appreciated very much visits paid to us by American metallurgists. Those of us who have been fortunate enough to make occasional visits to this side have invariably found the metallurgists here keen to discuss their work, experiences and problems.

Steel – My links with ferrous metallurgy have been connected with user interests, mainly in aircraft and defense applications. The two world wars (especially the second one) necessitated, *inter alia*, economy of alloy additions. We learned much about the better use of addition elements in steel. In recent years a field of considerable activity in European countries has been nitrogen control in converter practice, followed by developments in the direction of simple enrichment of the converter blast with oxygen up to 30 to 40%, replacement of the air blast by a mixture of oxygen and superheated steam, replacement of the air blast and the tuyeres in the bottom of the converter by a jet of pure oxygen injected into the vessel from above, and a variation of the latter by use of a more or less horizontal cylindrical vessel revolving on its own axis while oxygen is injected into the metal.

The scope and future utilization of these techniques appear likely to be influenced very much by their relative adaptability to the various types of pig iron, their ability to consume steel scrap, the availability and price of scrap, relative cost of fuels and electricity (which is likely to be determined by progress of nuclear power), capital costs of plant including associated plant such as blast furnaces, and finally, in addition to the many associated economic factors, the willingness of users to take the products. I feel sure that many of you are well informed on these new trends in steelmaking, also on recent German work on vacuum treatment of molten steels.

Major metallurgical problems like the laws of nature know no geographical boundaries. Brittle fracture and stress cracking in mild steels and other steels up to the high-strength steels have engaged and are engaging much attention in Europe. I would call the outstanding work of G. L. Irwin and his collaborators to your notice. Those of us concerned with aircraft applications are much concerned about the protection of the ultra-strong steels against corrosion without damaging them and how to use effectively their very high stress resistance. For very fast aircraft and vehicles where dynamic heating is a vital factor, the use of steels as main materials for primary structures is involving much experimental and development work. In this field, fabricating and handling properties are of special significance.

The gas turbine greatly stimulated the development of heat resisting steels and alloys in the United Kingdom – as indeed it did in the United States. In many ways there are striking parallels between developments in gas turbine materials in these two fields of intense activity; there are differences, too, but I will not take up time on these. For high-temperature blading, designers appear likely to use improved materials up to the limits of safe temperatures and stresses in cooled blades in their desire to operate with higher gas temperatures. For aircraft turbines, materials resistant to cracking due to thermal cycling are required; here again increased gas temperatures have brought greater incidence of thermal cracking. In turbines for power stations the conditions in this respect are less arduous.

In Europe as elsewhere there is interest in predicting long-time high-temperature creep and stress-rupture performance in long periods, but at present I think no users are relying on calculated performance based on short time tests.

Nonferrous Metals – In Europe utilization of aluminum and aluminum alloys as materials of engineering construction continues to advance. The alloys have not changed much in recent years but there is a great deal of interest and activity in the United Kingdom in the very strong Al-Zn-Mg type. Much study has been given to the influences of compositions and heat treatment on stress-cracking tendency, and to transverse properties in wrought forms (especially forgings).

Magnesium makes progress. After World War II production stopped in the United Kingdom and in Germany. British consumption now exceeds our production by a substantial amount. There is much use of the newer creep-resistant alloys at raised temperatures in aircraft and other work.

Titanium production proceeds on a modest scale in the United Kingdom and in several other European countries. The future scope of activity depends very much on the properties of titanium alloys as engineering materials, and especially on their suitability for general fabrication techniques – particularly sheet manufacture and manipulation. For service under stress at elevated temperatures at which some of the

alloys have attractive properties, we are bothered by the tendency to embrittlement of some of the alloys under service conditions, and are studying its various causes and significance. Much is owed to American research and development work on titanium, from which valuable guidance has been afforded, particularly to users.

The metals and materials required in atomic energy work and the changing fashions in that area have given much scope for the exercise of skill by metallurgists and other materials experts. From what little is publicly known about hydrogen fusion for power purposes, and the easy and casual references to temperatures of 50 to 100 millions of degrees in media circulating in toroidal channels, there seems to be no likelihood of any lack of materials problems. Major difficulties will likely be connected with preservation of the containing materials and of the required heat exchanger devices.

Science of Metals – There is much interest in Europe in the fatigue of metals. A group operating under the Organization for European Economic Cooperation is organizing an international group for extensive studies of cumulative damage by fatigue in steel and light alloys. Several countries will be participating. Corrosion fatigue studies, inspired by the work of J. D. MacAdam, Jr. at the National Bureau of Standards in Washington many years ago, were made by Gough and Sopwith at the National Physical Laboratory and by colleagues and myself at Farnborough but were not pursued through the war years. Studies have now been resumed, particularly on aluminum and magnesium.

G. I. Taylor little knew when he delivered his classic paper on dislocations in 1934 what new interests and activities he was triggering. The study of dislocations, the new techniques of electron microscopy, electron beam bombardment and X-ray fluoroscopy have opened up new lines of approach to fundamental problems and their understanding. American work in this forward-looking scientific field is eagerly followed by students in Europe. It may be that the present generation of "practical" metallurgists is not yet able to translate the information emerging from the more highly scientific work into better or more economic operations. It can at least be said that in a number of special fields – for example, in materials for electronic and electrical purposes – such advantage is being taken and is of real value. It can further be said that the light thrown out by highly scientific work on practical problems is very difficult to measure, but it is there and has effect.

Book Review . . .

Order-Disorder Science Simplified

Reviewed by *J. B. NEWKIRK**

ORDER-DISORDER PHENOMENA, by E. W. Elcock, John Wiley & Sons., Inc., New York, 1956. 166 p. $2.50.

It was the author's intent that this small review volume should appeal to a wide variety of readers. To this end he has kept his treatment of ordering phenomena in alloys quite general and has avoided the complex mathematical manipulations employed by many of the theoreticians contributing to this branch of metallurgy. Consequently, most of the presentation makes for rapid and pleasant reading. One agreeable feature, which other authors could well adopt, is the policy of outlining the contents of each chapter at its beginning and summarizing the chapter at its conclusion.

In the first three chapters the subject of binary alloy ordering is introduced at, I would estimate, the college level, developed with regard to specification and determination of the state of order, and described in terms of the Bragg and Williams

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and the quasi-chemical theories. Most of this part is based on the treatments of the classical A_3B and AB type alloys as reviewed by Nix and Schockly in 1938. The discussion is confined to equilibrium states and therefore a great number of interesting phenomena associated with non-equilibrium processes in ordering alloys are passed over. Chapter 4 describes extensions of the theories to nonstoichiometric compositions. A little experimental work (CuAu and Cu_3Au) is reviewed which demonstrates that the theories presented are not accurate. The entire final fifth chapter is devoted to magnetic analogies.

The monograph is admittedly an abbreviated treatment of order-disorder science and therefore is not a comprehensive survey. Only 11 references are given in the bibliography, and these are to review papers. Since some of the subject matter in the text does not appear in any of the reviews cited, it would have been helpful if the author had documented his remarks throughout the text with specific literature references.

Though much of the usual complex mathematics is omitted, I suspect that most metallurgists of the old school will still find the theoretical treatment unintelligible. The magnetic analogies, though interesting, are dangerous to use for any more than their curiosity value since the basic laws governing order-disorder differ widely in many respects from those governing magnetism.

Those who have read this far will have gathered that this little book is for the beginner. The more advanced readers will, of course, rely upon more advanced texts, such as Barrett's "Structure of Metals".

Report on Powder Metallurgy in the U.S.S.R.

*By HENRY H. HAUSNER**

"Self criticism", Russian style, of the knowledge and practice of powder metallurgy as of 1953, calls attention to deficiencies in meeting the aims of the last five-year plan. Indications in subsequent literature show that many of these deficiencies are being rapidly corrected. (H general)

THIS REPORT on the state of powder metallurgy in Russia is based on (*a*) a considerable amount of "background" information about the processes used in Europe and America acquired during my working life; (*b*) a critique of the industry and its scientific foundations given by Prof. V. S. Rakovski, a leading metallurgist and academician before a meeting in Kiev in 1953; (*c*) a discussion with Prof. G. A. Meerson of the Moscow Institute of Nonferrous Metals and Gold in Geneva during the 1955 Atoms-for-Peace Conference; and (*d*) a watch of the various abstract journals for Russian articles on the subject of powder metallurgy.

The general conclusion is that Russian scientists, technologists and industrial managers are working hard to overcome the deficiencies noted by Professor Rakovski in 1953, and that powder metallurgy in the U.S.S.R. is steadily growing, and growing in importance faster than in other countries, including the United States. Strong efforts are being made to get a better understanding of the basic principles. Furthermore, the powder metallurgy techniques are not only used for the mass fabrication of machine parts, especially for agricultural machinery, but also

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for parts for resisting high temperatures and for nuclear engineering.

Professor Meerson has recently sent me two books, collections of papers presented at meetings held in 1953 and in 1956. They show that there is not a single method now known to us which has not been carefully investigated in the U.S.S.R. For example, hydrostatic compacting for the production of turbine blades has been extensively studied in governmental laboratories. Improvement of cermets – especially mixtures of metal and metal oxide – seems to get an important share in the Russian programs.

From the literature available to me I cannot say that powder metallurgy in Russia is much further advanced than in the U.S., but I am inclined to draw the conclusion that powder metallurgy over there is at least at the same stage of development as it is here, and is growing at a very rapid rate. Very strong efforts, especially, are made in the direction of theories which lead to a better understanding of the basic principles in powder metallurgy.

Status in 1953

It would appear that the 19th Congress of the Communist Party of the U.S.S.R. "confirmed the directives concerning the development of our industry for the years 1951 to 1955, which foresee an important technical development of all branches of our economy" (to quote a translation of Professor Rakovski's 1953 address). "The guiding ideas in the development of our technology are automation, mechanization, and intensification of manufacturing processes. These directives call for the creation of new tools, machines, and high-quality materials – especially refractory alloys. In this technical development, powder metallurgy will play an important role." Rakovski then assesses the conditions as they existed midway in that five-year plan.

He first examines the foundations of the art of pressing and sintering as formulated by four leading theoreticians, and finds them all lacking. (Many of his remarks could be similarly applied to the situation on this side of the Atlantic, especially those in connection with the fact that one still does not understand very well the basic principles of sintering, and that considerably more work is necessary. Even so, I would say that the basic factors determining the powder compacting processes are more intensively studied in the U.S.S.R. than in any other country, perhaps with the exception of Germany.) Practically nothing is known, theoretically, about the nature of hydrostatic pressing, the influence of exceedingly high unit pressure – especially in the possibility of creating plastic materials from brittle ones – or the pressing and sintering of oxidized powders. He then cites the following main problems needing investigation:

1. To establish a relationship between the main operating conditions and the behavior of the particles being pressed.
2. To determine and explain the effect of exceedingly high pressures on plasticity.
3. To devise a theory underlying such new methods of pressing as hot pressing and vibratory compacting.
4. To extend the theory to include the sintering of powder mixtures of various degrees of mutual solubility.
5. To study the influence of ultrasonics on the mechanism and kinetics of sintering. "It is known that ultrasonic vibration will cause an alloy to crystallize in micrograins, and its bulk properties are considerably improved. The sintering of particles of completely different materials is considerably activated by ultrasonics. No theory has been developed at all, even for such important practical matters as mixtures of metals and oxides."
6. To extend knowledge about the mechanism of diffusion during sintering of mechanical blends, solid solutions and chemical compounds, with the help of radioactive isotopes and microspectroscopy, and to correlate theory with observed facts.
7. To establish recrystallization diagrams correlating to grain size, pressure during pressing, and sintering temperature for one-component systems, solid solutions, mechanical blends, and chemical combinations.

Professor Rakovski concludes this portion of his address with the exhortation: "Our science should become first in the world!"

Industrial Requirements

Next, Professor Rakovski turned to the technological problems faced by the Russian powder metallurgy industry before the requirements of the five-year plan could be met. These he subdivided according to the general directives of the 19th Congress of the Communist Party.

Automation, he said, requires complicated electronic instruments, photo-electric cells, magnetic apparatus, and a variety of other equipment in which the products of powder metal-

lurgy find a wide application, especially special magnets and parts made of refractory and rare metals.

For example, rolling sharply increases the permeability of magnetic materials. Manufacture of strip directly from powders by rolling should lead to new materials with very favorable magnetic properties. Such manufacture requires iron powder manufactured by electrolysis – at present insufficiently perfected.

"**Mechanization** is the second guiding idea of the 19th Congress. This means the mass production of powerful excavators, bulldozers, drills, transporters, and a number of other machines. Powder metallurgy products are needed in an overwhelming majority of these.

"The coal industry has successfully developed cheap iron-graphite bearings for conveyers, replacing expensive ball bearings and roller bearings, poor in quality, and it now has an important plant manufacturing porous bearings.*

"Integration of industry to produce iron powder is most desirable. Five methods are in pilot plant or production states: (*a*) reduction of mill scale by hydrogen in a rotating furnace; (*b*) reduction of mill scale by natural gas; (*c*) reduction of mill scale by carbon; (*d*) reduction of Krivoi Rog iron ore with soot; (*e*) atomization of molten cast iron. The output of a plant now using the first-mentioned process is quite inadequate, yet the product going into the bearing plant of the coal industry has already saved over 15,000,000 rubles. While methods (*b*) and (*c*) appear to give the best quality powder at lowest cost, a decision should be promptly made as to which process should be selected for centralized production, and acceptance standards adopted.

"**Speed-up** is the third guiding idea. This can frequently be done only by using such special materials as metal-ceramic hard alloys (cutting tools), highly refractory materials, wear resistant antifriction parts. All these pose new technical problems for the powder metallurgist.

"For example, antifriction materials are made by pressing a metal-ceramic layer on a steel base. For large parts this means powerful presses, which are not always available. Preliminary tests show that the metal-ceramic layer can be put on with the help of high-frequency currents.

"To sum up, the important technical problems of powder metallurgy in the U.S.S.R. are as follows: Produce iron powders, magnets, electrical contacts on a large industrial scale; create new types of refractory alloys; develop on an industrial scale the method of powder rolling, the method of applying metal-ceramic layers by high-frequency currents, and the method of hydrostatic pressing.

"Certain recent achievements are worthy of mention. The automobile industry has started using composite bearings with a layer of lead bronze produced by powder metallurgy. These are in no way inferior to cast bronze bearings and reduce metal consumption by 90%. Automotive parts are also pressed from shavings, a byproduct of the ball bearing industry. Watch parts are made in a similar way.* Byproducts in powdery form are going into high-quality welding rods."

Organizational Problems

Here again, the comments of Professor Rakovski are summarized to indicate the need of several central manufacturing units. For example, in the Ministry of Machine Construction, it is advisable to create a central plant for metal powder products meeting the standards of that ministry. Likewise, the Ministry of Transport and Heavy Machinery should have a centralized production primarily of antifriction bearings, and the Ministry of Electrical Industry and Power Stations should centralize the production of electrical contacts and miscellaneous magnets. Production of iron powder on a sufficiently large scale under the control of the Ministry of Metallurgy must be expedited. At the same time, these agencies should institute large research laboratories specializing in powder metallurgy.

Another problem relates to technical education and preparation of specialists. Students of

*Editor's Footnote – One might suspect that the good professor is a little loose in his figures. He says "The production of porous bearings from iron powder by the Ministry of Coal Industry is responsible, within a short time, for savings over 15,000,000 rubles to the People's economy." Perhaps a disregard about money is a common failing in a noncapitalistic society. For example, *Metal Progress* for January 1957 quotes a Russian document on spark cutting and toughening thus: "Cost of plant for economical working: 1000 to 3000 rubles". This is $250 to $750. Maybe, over there, there is a different value of the ruble depending on whether you spend it or do not spend it.

*Fine shavings are apparently a fairly common metal "powder" in the U.S.S.R. A recent article (1955) on grain size determination notes that "agreement of the test with microscopic measurements was poor for aluminum powders, as they were in the form of spiral-shaped shavings".

Table I – German and Soviet Types of Carbide

Symbol	Content WC	Content TiC	Content Co	Rockwell Hardness	Bending Strength, 1000 Psi.
T5K10 (Russian)	85%	6%	9%	C-90.5	190 to 200
L3 (German; old symbol S3)	88	5	7	88.5	165
T15K6	79	15	6	90	210
L2 (German; old symbol S2)	77 to 78	14 to 15	8	88 to 90	155 to 175
WK8 (Russian)	92	—	8	91.5	165 to 190
WK6 (Russian)	94	—	6	87 to 88	185 to 210
WK3 (Russian)	97	—	3	87.6 to 88	170 to 200
G1 (German)	94	—	6	89 to 90	140 to 150
H1 (German	94	—	6	90	230 to 235
H2 (German)	91.5	—	7	91	210 to 230

institutes for machine construction are generally unaware of the modern methods of powder metallurgy, and it is imperative that the curriculum of metals technology include courses on this subject.

Finally, information should be systematically published. A special committee on powder metallurgy should be created within the Presidium of the Academy of Sciences of the U.S.S.R., having power to control the study of the more important problems, to organize scientific discussions, to publish textbooks, and to organize contests.

Recent Progress

So much for conditions in Russia four years ago. An increasing number of abstracts of Russian articles about powder metallurgy have been published in the *Metallurgical Abstracts* of the British Institute of Metals, *Chemical Abstracts*, and other abstract services, as well as listed in *Review of Metal Literature*. Important recent publications deal with problems in manufacturing metal powders and the phenomenon of sintering. For example, emphasis is given in one paper on "acceleration of sintering", a process which we call "activated sintering". Another notes that sintering can be accelerated by small additions to the compact which migrate rapidly, affect the activation energy of the main particles and hence their mutual contact surfaces. For example, density and structure of sintered carbonyl iron powders are improved by adding a little ferric chloride. Another mixture of two parts of fairly coarse copper turnings and one part brass was immersed in molten borax at 1800° F., resulting in compacts with shear strengths of 37,000 to 42,500 psi.

In our conversation at Geneva, Professor Meerson, who has worked on the powder metallurgy of thorium, told me that the Russians are also studying the powder metallurgy of uranium; however, in comparing our publications in this field, he thinks they have not advanced as far as we have. He presented a paper on the powder metallurgy of thorium at the Geneva Conference (Vol. 8, p. 188), in which he reported on the physical properties of sintered compacts made from electrolytic and calcium-reduced thorium powders, respectively. Both powders were of 99.6 to 99.7% purity, and contained, with the exception of calcium, the same impurities in practically identical amounts. Electrolytic thorium powders showed a considerably higher "sinterability" than the calcium-reduced powders, by that meaning that strength and hardness of sintered (or re-pressed and annealed specimens) are considerably higher, even though the density is substantially equal. The great interest of the Russian metallurgists in thorium indicates the interest of their nuclear reactor engineers in the development of breeder reactors.

Much attention is also being given currently to cermets, borides and carbides – especially tools made of the latter. It should be mentioned that the Russian and German standards for sintered carbides are very similar. Table I compares the two, and it may be helpful for a better understanding of the Russian powder metallurgy literature. The Soviet carbide designation is based on chemical composition. Letter symbols have the following meaning: W = tungsten carbide; T = titanium carbide; K = cobalt; and N = nickel; after the letters the binder content is given in percentage.

The *American Machinist* for Sept. 24, 1956, reported; "Compared with German standard carbides, the Soviet carbides of the same hardness have a lower bending strength. Their usefulness may be less than (*Continued on p. 196*)

Iron and Steel Needs of Argentina

*By JUAN B. DE NARDO**

In the late 1920's Argentina produced only 10% of its needed iron and steel. Now it makes about 30%. Future deficits will be reduced when the San Nicolas steel mill starts production. Annual needs for 1,200,000 metric tons are predicted during the 1960 decade. (A4p, D general; ST)

It is the author's intention to present a brief summary of the recent history and the present status of the iron and steel industry in Argentina, in order to clarify the existing needs and predict the possibilities. The review will limit itself to the years since 1943. Up to that date the metallurgical industry was pitifully neglected. For example in the prosperous years of 1927 to 1929 Argentine imports of iron and steel averaged 1,200,000 metric tons annually. In those same years we exported 51,000 tons of scrap iron and steel, yet during World War II we paid as much as 1000 pesos per ton for scrap rail!

However, the steel industry began to receive governmental attention in 1943, as indeed was necessary to carry out the transition from an economy based on agriculture and cattle to one based on heavy industry. Even though considerable progress was made during the 1946-1955 decade, a large deficit still existed in all the major classes, as shown in Table I. From those figures it is apparent that we were actually able to produce less than one third of the country's needs. The rate of growth from the period prior to that shown in the table is rather impressive (prior to World War II we produced a bare 10% of the country's needs), but since 1954 the rate of expansion has almost stopped. This is a matter of no small concern, since careful estimates of the country's needs by the year 1965 come to 1,200,000 metric tons per year. If the amount of steel which can be imported is to be limited, then Argentina's own metallurgical plants must be expanded. The alternative is to handicap our industrialization severely.

Steel Capacity – Pending the blowing-in of our new steel plant at San Nicolas, the present production capacity of the various plants in Argentina, including the government's plant at Villa Lugano Arsenal, is as shown in Table II. A sincere attempt has been made to give realistic figures in the last column; it seems impossible to get really accurate statistics. For one reason, the length of a campaign is not exactly known; certain furnaces are shut down for relining or major repairs after 100 to 150 heats, while others of the same type making substantially the same product may run for 200 to 300 heats. (This large variation is not due completely to differing quality of the refractories; the skill of the furnace crew and its management also plays its part.) A second reason for inaccuracy is the shutdowns caused by strikes or labor troubles, while a third resides in the

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variable amount of mill scrap or off-heats.

Pig-Iron – Assembling the figures for annual pig iron consumption for the period 1940 to 1956 we find the following:

Furnace	Pig on Charge	Annual Consumption
Openhearth	20 to 30%	32,500 tons
Bessemer	0 to 100	2,000
Electric	15 to 25	2,100
Others	5 to 25	1,500
Foundry cupolas	0 to 50	20,000
Total*		58,100 tons

Argentina has only one small blast furnace, located in Palpala, Province of Salta, and operated by the Military Administration (Direccion de Fabricaciones Militares). In its best year it produced 32,000 metric tons of pig iron during this same period. The annual deficit has therefore been considerably more than 25,000 tons. If the governmental program calling for 150,000 tons of pig iron annually is reached, the deficit will be about 120,000 tons until additional blast furnace capacity is installed. We have the necessary raw materials in ore from the Rio de los Tomates district and coal from Rio Turbio.

Production of the Palpala furnace is all of low-sulphur iron (0.05 to 0.06%) and in four general types, depending on silicon content. (An added advantage of more blast furnaces would be that the wider needs of the entire industry could more nearly be met.) Present production is as follows:

	Type I	Type II	Type III	Type IV
Silicon	0.35-0.50	0.75-1.5	1.2-2.0	2.0-4.0
Carbon	3.2 -4.0	3.5-4.2	3.5-4.2	3.5-4.2
Phosphorus	1.0	0.7-1.3	0.7-1.5	0.6-1.5
Manganese	>0.20	>0.40	>0.40	>0.40

*This figure of 58,100 tons is for the 1940 to 1956 period while the figure of 65,000 tons is for the 1946-1955 decade.

Table I – Annual Consumption and Production, 1946-1955
(1 metric ton = 0.98 long ton = 1.1 short ton)

Type	Consumption	Production	Deficit
Pig iron	65,000	23,000	42,000
Iron castings	165,000	80,000	85,000
Rounds and squares	229,500	90,000	139,500
Plates	136,500	10,500	126,000
Structural shapes	80,000	20,000	60,000
Tubes	70,000	20,000	50,000
Other shapes	35,500	3,100	32,400
Alloy steels	5,500	1,200	4,300
Totals	787,000	247,800	539,200

Table II – Production Capacity of Argentine Industry

Type of Furnace	Number Existing	Maximum Size, Tons	1956 Production, Tons
Openhearth	28	300	170,000
Bessemer	11	13.75	4,000
Electric*	39	26.5	12,000
Crucible furnaces†	?	—	1,000
Foundry cupolas	150	215	80,000

*Including small induction furnaces.
†Used for melting alloy steels.

Scrap—In addition to the above materials—in fact, to produce some of them—iron and steel scrap is consumed in very considerable tonnages. I compute the average to be almost 215,000 tons annually. This supplements our pig iron not only as melting stock, but considerable amounts of low-carbon steel scrap are faggoted and rolled into small merchant shapes. This tonnage of scrap is becoming increasingly difficult to collect in a country whose consumption of new iron and steel products in the last 30 years has seldom reached 1,000,000 tons annually.

Industrialization—To get a better panorama of Argentine industry it may be said that during the 1943-1954 period the value of the industrial production of ferrous materials and machines, tools and other items made therefrom grew at a rate three times as fast as the returns from the agricultural and cattle-raising industries of Argentina. Some branches of industry have increased 37-fold. This explains the exodus from the country into the big cities or industrial centers. Salaries and wages are better and more comfortable living quarters are to be found. It has also accentuated the needs for iron and steel, for the per capita demands of a city dweller (when including municipal services) are much greater than the rural inhabitant.

Some figures from the latest industrial census may be worth quoting. The respective figures relate (*a*) to metals and their manufacture and (*b*) to machinery and related equipment.

	Metals	Machinery
Number of shops	3,742	5,049
Employment	47,041	57,029
Earnings per workman*	1,150	1,550
Horsepower consumed	51,000	83,000
Value of raw materials†	106	105
Value of product	195	229

A Look Ahead — Analysis of the above figures should not lead us to an exaggerated optimism. Metallurgy in Argentina is a "war baby" in the sense that the first attention was given to it only by virtue of the imperative needs of wartime. From 1939 to 1943 we were an emergency industry and we sacrificed quality for quick production of many items. We corrected our mistakes "on the run," as you might say.

We now have a stable industry, though it may not loom very large in the eyes of Americans, Germans and Englishmen. It consists primarily of a multitude of small shops. To achieve this situation a tremendous amount of good work has been done since 1944. To retain our gains and to improve upon them, as we must, several things need to be done:

1. Improve our standards of quality.
2. Balance internal production and foreign importation to achieve a minimum over-all cost to the national economy.
3. Develop the mechanical industries without friction with the cattle and agricultural segments of the nation.

These are by no means impossible goals. In judging our future progress the observer should bear in mind that, up to 1943, Argentina's metallurgical industry was pitifully neglected. Prior to that time our businessmen could not see any profit in an investment in this field. Little or no protection was given by the Government.

Hence it has only recently been possible, now that these conditions are changed, to encourage an industry based on the large resources of excellent minerals which Argentina possesses.

*Average, in pesos. †In millions of pesos.

Ferromanganese From Lean Ore

*By B. R. NIJHAWAN**

India has exported about 1,000,000 tons of hand-picked high-grade manganese ore annually, but its large resources in low-grade ore could, when concentrated and smelted, be sold as standard ferromanganese and the value doubled. Numerous projects of this sort are in pilot plant or small production.
(B14, C21, 2-60; Fe, Mn, AD-n)

THE SLAG DUMPS, tailing heaps and discarded wastes of today are the mines of tomorrow. As the ores get leaner, ingenious new techniques are devised for extracting the metallic values. A multitude of examples in the last 75 years could be cited in all parts of the world. These remarks hold good for Indian manganese ores in particular which represent one of our biggest nonferrous mineral assets.

Excluding Russia, India probably ranks as the world's largest supplier of high-grade manganese ore. The substandard grades have hitherto been neglected or wholly discarded. Our high-grade ore is generally hand-picked from the ore blasted loose in open pits, leaving the low-grade ore on the site. For every ton of ore shipped there remain discarded one to two tons of low-grade ore. One single large exporter in the Madhya Pradesh province in Central India has accumulated over 6,000,000 tons of such waste. While remaining high-grade manganese ores have been estimated at about 60,000,000 tons left over after exportation of about 40,000,000 tons in the past, the reserves of substandard grades are very much greater. The manufacture, in India, of exportable grades of standard ferromanganese, rather than shipping the unsmelted high-grade ore, is a matter of utmost importance to the national economy. Mineral beneficiation and upgrading has only recently received much attention in India's second five-year plan for economic progress. Scientific work at the National Metallur-

*Director, National Metallurgical Laboratory, Jamshedpur, India.

gical Laboratory on the upgrading of our manganese ores forms an important part of the broad industrial development of Indian ferrous and nonferrous industries.

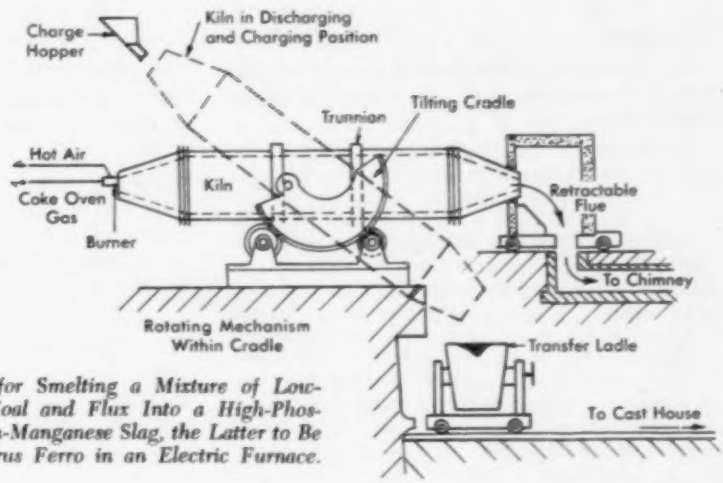
Without going into unnecessary details about location of ore deposits, their estimated reserves, and their average compositions, we can say that the 19 important ones fall into four broad classes, each of which has been rather carefully studied.

1. Siliceous ores whose gangue minerals are relatively light in specific gravity in fairly coarse particles: These are most easily handled by conventional gravity concentration – grinding, jigging, tabling (sometimes supplemented with magnetic devices).

concentration: Electrostatic separations (and sometimes flotation) are effective here.

4. Complex ores falling into two or all three of the above categories: Each of these is a separate problem; some of them can be handled by standard methods in sequence; some of them consist of such intimate mixtures of minerals as to indicate that direct smelting (like recovery of manganese from openhearth slags) will be the only effective means at present.

There is, of course, the possibility (which will not be discussed here) that any of these may be raw material for a combined beneficiation, smelting, and chemical process which results in electrolytic manganese metal.



Sketch of Rotating Kiln for Smelting a Mixture of Low-Grade Manganese Ore, Coal and Flux Into a High-Phosphorus Pig Iron and a High-Manganese Slag, the Latter to Be Reduced to Low-Phosphorus Ferro in an Electric Furnace.

2. Manganese ores high in iron with comparatively little gangue: Many of these can be ground, the fines (slime) removed, and the minerals separated in equipment based on the higher magnetic susceptibility of hematite. Others require a reducing roast to convert the iron minerals to magnetite. The latter scheme is also applicable to ores with substantial quantities of gangue containing neither manganese nor iron, in which two magnetic devices are necessary, one a low-intensity magnetic separation for the iron minerals, and the other, a high-intensity magnetic separation to pick up the feebly magnetic manganese minerals. It is obvious that this will result in a good iron ore as a valuable byproduct.

3. Ore containing appreciable quantities of garnet which cannot be separated from manganese minerals either by gravity or magnetic

The Phosphorus Problem

At the outset it must be said that ferromanganese now made in India (and used by the Indian steel industry) is high in phosphorus. Thus:

	Indian Ferro	American Standard Ferros
Manganese	70 to 75%	78 to 82%
Carbon	6 to 8	5 to 7
Phosphorus	0.5 to 0.6	0.35 max.
Sulphur	0.27 av.	0.05 max.
Silicon	0.55	1.25 max.

The high phosphorus comes from the metallurgical coke now being used in India. It contains from 0.18 to 0.25% phosphorus as compared to a maximum of 0.015% in American coke. It also builds up in the ferro because our smelting ore mixtures have about 50% Mn, 7% Fe and 0.10% P, and something over 2.3 tons of such

The Windscale Incident*

In 1947 to 1950 the United Kingdom built two plutonium producing piles at Windscale on the Cumberland coast of England near the Scottish border. Natural uranium is used for fissionable material, graphite for moderator, and air for cooling (a detail unlike the piles at Hanford, Wash., which are water cooled). Uranium slugs, canned in aluminum, are placed in round channels in the graphite mass, and air is blown through each channel and exhausted through glass wool filters in a 405-ft. chimney.

On Oct. 10, 1957, it was discovered that some of the uranium cartridges near the center of No. 1 pile were red hot. At the time the pile was shut-down for the "Wigner release", to cool the main mass of graphite.† It is well known that the neutrons given off when an atom of U^{235} splits are "fast" and must be slowed down to "thermal speeds" before they can be captured by the hundred-fold more numerous U^{238} atoms (which capture results in the creation of plutonium metal). This slowing down is the function of the carbon moderator, and the loss in speed reappears as heat. This heat is carried off by the coolant – air at Windscale, water at Hanford. However, a small portion of the energy is stored in the graphite, and to deal with this accumulation, the operators had arranged at about six-months' intervals a Wigner release.

The immediate cause of the accident at Windscale was a *second* nuclear heating too soon and at too rapid a rate, thus causing the failure of one or more cartridges in the pile, whose contents then oxidized slowly, eventually leading to a fire in the reactor.

All the uranium fuel cans were intact when the Wigner release was started on Monday, Oct. 7. It seemed to proceed normally and next morning the nuclear heating process was stopped. Then, as the Wigner release seemed to be dying, the physicist in charge decided on Tuesday morning to boost the release with a second nuclear heating.

The investigating committee concluded that one or more uranium cartridges burst during this second heating, from too rapid a temperature rise. (There were no thermocouples and hence no record of temperature in that part of the pile.) During Wednesday, the graphite temperature rose gradually, and the unprotected

*By Tom Bishop, Metallurgical Consultant, John Miles & Partners (London) Ltd., Consulting Editor, *Metal Progress.*

†Editor's Footnote – Collisions between fast neutrons and carbon atoms may displace the latter from their lattice positions and eventually change the shape of a block in its macroscopic dimensions enough to endanger the shielding structure or the clear running of slugs or control rods through the channels. Furthermore the carbon mass stores internal energy ("Wigner energy", so-called after the Princeton professor who first predicted the effect) in addition to thermal energy to such an extent that its combustibility increases. To correct these two effects the pile is run for several hours at a temperature sufficient to allow re-diffusion of displaced atoms and "evaporation" of the stored energy. Wigner energy can be released from an irradiated carbon block by merely baking, but the only way of heating the mass of carbon in a pile is by shutting down the reactor and then bringing it back to critical with no coolout, thus starting the "Wigner release" or "annealing" which is then self-sustaining. The behavior in the pile is followed by thermocouples strategically placed in the carbon mass. On three previous occasions at Windscale a second nuclear heating had been necessary to "anneal" satisfactorily the entire carbon mass.

coke are needed to produce a ton of ferro in a blast furnace. High iron in our ore mix and coke (about 2%) also dilutes the manganese.

Although India does not have coal with very low ash, and there is some coking coal with from 0.01 to 0.05% P, the large-scale manufacture of low-phosphorus ferro apparently also involves the problem of coal washing devices, blending with low-phosphorus coal from same source, or electric smelting with a minimum of such coke as can be made within our own country. Since some exportable ferromanganese has been made in India in the past, the problem is neither new nor impossible to solve.

Smelting Low-Grade Ore

Large amounts of manganese pass into slags from openhearth steel furnaces, and its recovery

uranium proceeded to oxidize. The uranium must have smoldered all day, and the heat so generated would have caused other cans to burst. By Thursday evening, the fire had spread to about 150 of the 950 channels. The surrounding graphite was also burning.

One thermocouple in the graphite was showing a steady temperature rise and by 10 p. m. on Wednesday the physicist in charge tried to correct matters by shutting off the draft of coolant through the pile. All graphite temperatures dropped except at the hottest location. At 6 o'clock on Thursday morning, Oct. 10, the meter near the stack filter showed a sharp increase in radioactivity – noted by the pile physicist who, however, took no action. This radioactivity fell for a couple of hours, and then it rose steadily.

It was now realized that a cartridge must have burst. A scanning gear to detect just such an event was jammed, immovable. Since the air leaving the pile was intensely radioactive the works general manager ordered that the affected channels be identified and cartridges in each discharged immediately. This identification had to be done visually after removing the end plug in the channel; red-hot uranium cartridges were seen, but they were so distorted they jammed in the passageways.

A fire-break was then created by emptying channels around the red-hot region. This checked the spread of the fire, but did not bring down the temperature of the hot area. Streams of carbon dioxide forced through the pile failed to extinguish the fire. Finally hoses were turned on at 9 p. m. Friday, Oct. 11, and continued for 24 hr. By Saturday afternoon the pile was cold.

The British Atomic Energy Authority has accepted the findings of its investigating committee and attributes the accident partly to inadequate instrumentation (especially distribution of thermocouples) and partly to faulty judgment by the staff. On the latter point, the Penney Committee commented upon the absence of a section on Wigner release – very infrequently done – in the detailed pile-operating instructions. A new committee is to collect data and recommend the standard procedures for carrying out future Wigner releases and to make recommendations about restarting of Windscale Pile No. 2, which was shut down after the accident to its sister pile. A second committee will go into questions of health and safety. No announcement has yet been made of plans to repair or reconstruct Pile No. 1.

The steps taken to deal with the consequences of the accident to the workers and the inhabitants of the Windscale area were also investigated by the original investigating group, the Penney Committee. The health-physics department found that 14 men had received the maximum permissible dosage of 3 r. (roentgens) in the 13-week period including the incident; the highest individual figure among those men was a dosage of 4.66 r.

A British Medical Research Council report approves all the actions taken by the health-physics staff of Windscale. It believes that there was no risk from gamma rays in the Windscale area, as a whole, or from particles that might be taken into the lungs. Some radioactive material (mainly radioactive iodine) escaped the filters and was deposited on the ground around the factory so milk from herds in the vicinity was destroyed. Restrictions on use of this milk were removed on Nov. 23. The Council is satisfied that no one has received any dangerous dose of radioactivity.

The accident at Windscale has no bearing on the safety of the nuclear power stations being built for the British Electricity Authorities because these are of later design, are not air cooled, the coolant is in a closed circuit, and the plants are more efficiently instrumented.

has received considerable attention in the United States, Australia and Germany. Early ideas were that such slags, with or without low-grade manganese ores, should be smelted in a blast furnace under conditions which would reduce most of the iron and phosphorus but little of the manganese, thereby forming an enriched manganese slag which could then be smelted into ferro of standard analysis. More promising developments have been based on a three-stage process: first, smelting in a blast furnace to produce a high-phosphorus spiegeleisen; second, preferential oxidation of the latter in a converter or openhearth furnace to produce a high-manganese slag low in phosphorus and iron, and finally, producing standard ferromanganese from this slag in a blast furnace.

Licenses have been issued under the Second

Five-Year Plan to nine Indian firms to produce ferromanganese in this three-stage process, looking toward a total production of about 170,000 tons annually.*

Our own work at the National Metallurgical Laboratory has been toward the smelting of low-manganese ores into an enriched slag (with pig iron as a useful byproduct), and the slag is then smelted in an electric furnace. We believe that on a commercial scale, the first function can be done in a Krupp-Renn rotary kiln under acid conditions, and the second in a basic electric furnace. Our planned pilot plant for the first stage, the rotating kiln, is sketched in the drawing on p. 113.

A mixture of crushed ore, coal or coke and flux is charged into the rotary kiln in its tilted position. Returned to horizontal, the burner (coke oven gas and hot air) is thrust into the charge end and the dust catcher and chimney connection rolled left into position. Rotation of the kiln starts. When the charge is melted the burner and flue are retracted, the kiln again tilted and molten contents pour out into the ladle car waiting below. The next charge then enters the upper end of the kiln; this kiln would have a monolithic lining.

The ladle goes to the casting department where the slag is granulated and the iron is run into pigs in a sand bed. The granulated slag is then to be used in an electric (or blast) furnace for production of ferromanganese; in view of the high phosphorus in India's coking coal the electric furnace (using a minimum of carbon for reduction) would probably be preferred.

Raw materials would be ores from Northern Orissa (about 175 miles west of Calcutta), low in manganese (33%), high in iron (23%). Flux would be limestone and bauxite. Reducing agent may be coal, coke or coke breeze. Fuel for the kiln will be coke oven gas.

In this connection we should mention work now under way by Tata Iron & Steel Co., Ltd. looking toward large-scale production of ferromanganese in a low-shaft furnace. The process appears to offer the following advantages:

1. The possibility of using a wider range of manganese ore.

2. The manufacture of the alloy in separate self-contained units.

3. It will require low-phosphorus fuel (coal rather than coke) and India has considerable amounts of such noncoking coal available.

In experimentation done in Germany, the charge was briquetted prior to smelting in the low-shaft furnace. While an alloy low in phosphorus was produced, excessive slagging of manganese reduced the alloy to about 65% Mn. Further trials, however, have shown that these oxidation losses can be reduced through suitable additions to the charge. The low-shaft furnace of Gute Hottnungs Hutte at Oberhausen (West Germany) has produced at the rate of about 50 tons per day.

Economics

While about a million tons of high-grade manganese ore are currently exported from India, if it could be converted to exportable grades of ferromanganese (phosphorus below 0.3%) it would bring at the current prices at least double the cash returns. The economic benefits accruing thereby are evident.

This is apart from the fact that suitable methods for the utilization of waste manganese ores would also be evolved which in itself would be one of the greatest economic assets to the country. During the Second Five Year Plan when the ingot steel production is to be stepped up to 6,000,000 tons, the corresponding ferromanganese requirements will rise to roughly 100,000 tons of ferromanganese. It would be thus seen that, at the scheduled production capacities of existing ferromanganese licensees (170,000 tons maximum) there will not be a great bulk left for export. Production of exportable grades of ferromanganese should be stepped up to 300,000 tons a year. This would, in due course, fully meet the projected demands for ferro for the Third Five Year Plan, wherein the ingot steel production is stipulated at 15 million tons, and would still leave a considerable surplus for export.

*In this connection, it might be mentioned that a two-stage pilot plant has been operating with considerable success in Australia (Broken-Hill Proprietary), smelting openhearth run-off and finishing slags into a 70% ferro. The charge averages 28% FeO and Fe_2O_3, 31% MnO, 2% P, 21% SiO_2, and 17% base (principally CaO). In the first stage iron and phosphorus are reduced in an acid furnace at low temperatures. This forms stable manganese silicates which enter the acid slag. This slag is reduced in the second stage under highly basic conditions to an alloy containing about 70% Mn, 16% Fe, 11% Si, 3.6% C and 0.3% P. The metal from the first stage is suitable for many high-phosphorus iron castings; the slag from the second stage makes good cement. Considering the value of these byproducts, the cost of the ferromanganese is not so high as to be prohibitive.

Personal Mention

Edgar C. Bain

News that Edgar Bain has retired from his position as "Assistant Executive Vice-President, Operations, U.S. Steel Corp., in Charge of Research and Technology Div." brings also the comforting note that from now on he plans to spend half his time on some of the many challenging metallurigical problems which confront industry, and the rest on writing, music and photography. In this way his proven usefulness to American science and technology will continue unabated.

Looking back in the files of *Metal Progress,* I find a biographical appreciation in 1936 when he was president of the American Society for Metals. It was long (four pages) but not nearly as long as a "Profile" in the *New Yorker*. It was also different in that the man written about was a man of very real importance. At that time, 20 years ago, he had already made a reputation as a penetrating student of toolsteels, stainless steels and engineering alloy steels, and then as an executive, having been in charge of metallurgical work at the Corporation's main research laboratory at Kearny, N.J., since 1928.

The present writer treasures in his working library two technical books which he believes to be epoch-making. One is "The Science of Metals", by Zay Jeffries and Robert S. Archer (1924). The other is "Functions of the Alloying Elements in Steel", by Edgar C. Bain (1939). These two have this in common: Each collected a multitude of scattered facts and reduced them to system. These are pioneering books in a real science of metals.

Then, too, he remembers his keen delight in the studies of isothermal transformation of steel which suddenly clarified a muddled ocean of wordage about beta iron, troostite, sorbite and the rest. It was ample justification for christening the actual transitional constituent "bainite" – a term whose use testifies the universal acceptance of the findings made under his direction and with his actual participation.

Such a man gathers responsibilities as acorns draw squirrels. Ed Bain became vice-president of research and technology of Carnegie-Illinois Steel Corp. in 1943 and presided over the rapidly expanding research effort in that large segment of the steel industry which culminated in United States Steel's research center in Monroeville, near Pittsburgh, where the inspiring building at the very entrance to the group is fittingly named the Edgar C. Bain Laboratory for Fundamental Research.

It must also be a matter of deep satisfaction to him that his professional brethren at home and abroad have seen fit to honor these achievements. He received the gold medal in 1949. In 1952 the French awarded him the Grand Medaille de la Societe Francaise de Metallurgie. He delivered the Hatfield Memorial Lecture in Sheffield, England, in 1955, and has recently been elected to membership in the National Academy of Sciences of the United States.

E. E. Thum

G. D. Moomaw has retired as manager of the Baltimore, Md., works of Armco Steel Corp., after 45 years in the steel business. Mr. Moomaw has been manager of the Baltimore stainless steel plant, then the Rustless Iron and Steel Corp., since 1939. The company became part of Armco in 1945.

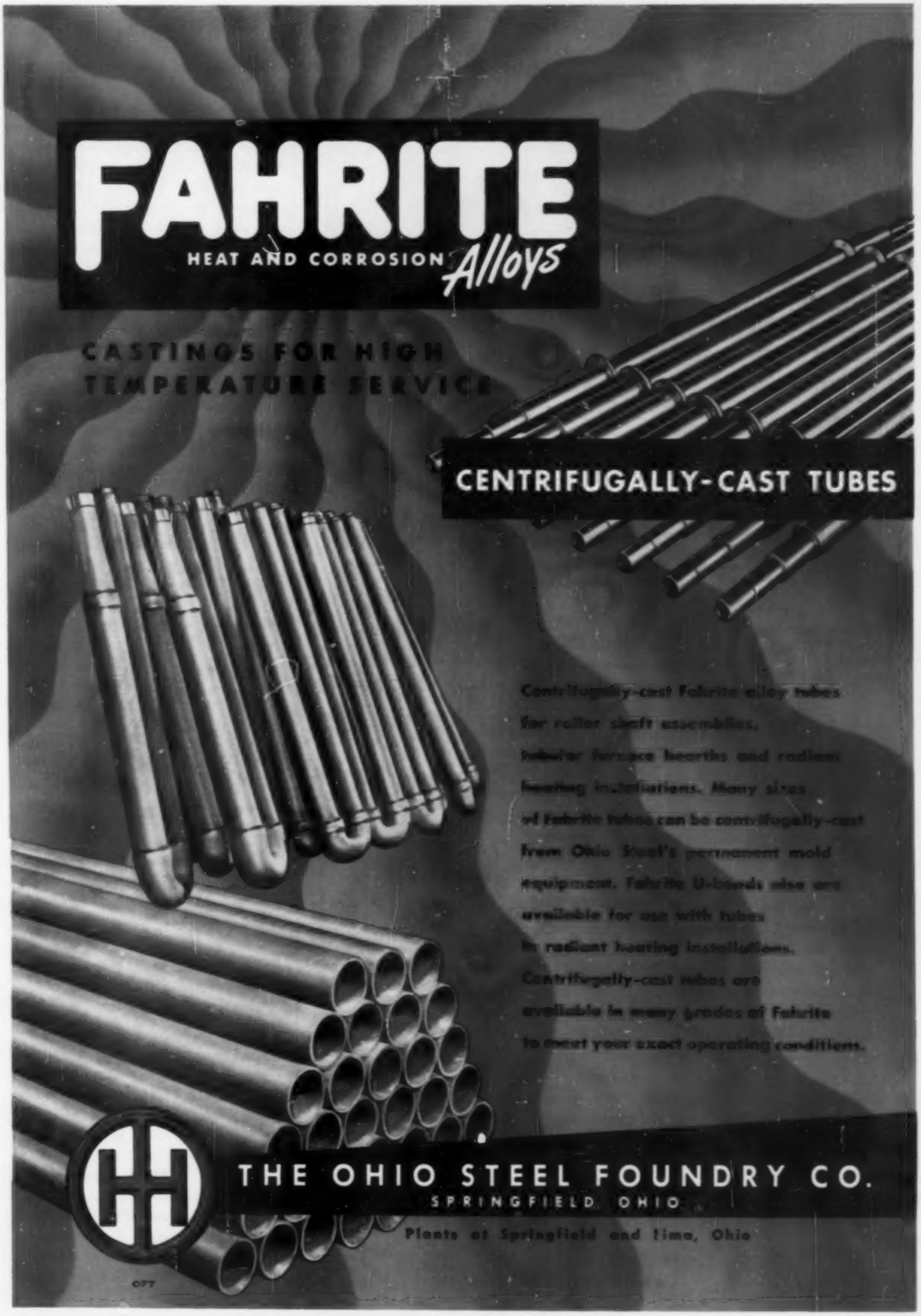
Tita Binz

Edouard Houdremont

The appearance of a third revision of the German authoritative book on special steels ("Handbuch der Sonderstahlkunde", 2 volumes, 1538 pages, published by Springer-Verlag, Berlin) warrants a few words about the author and the book. Edouard Houdremont was born May 19, 1896 in Luxembourg and received his doctorate in metallurgical engineering at the Technical University of Berlin in 1921, whereupon he entered the employ of what is now called Deutsche Edelstahlwerke at Krefeld. Five years later he accepted the position of assistant manager of the Krupp Works in Essen, rapidly rising in the executive ranks, becoming a member of the executive board of the corporation during World War II in charge of all metallurgical divisions of that important steel and iron combination. Since the war he has established a practice as consultant, being also scientific advisor to the Max Planck Institute for Iron Research in Düsseldorf and special lecturer at the Technical University of Aachen. One of his prized honors is his recent election as corresponding member of the French Academy of Sciences.

His early work on the commercial production of weldable austenitic stainless steels led to extensive work between 1930 and 1945 on materials for a chemical plant to operate under very high temperature and pressures, and—especially in wartime—on the economical use of scarce alloys in steel manufacture. All this work is reflected in the pages of the "Handbook".

The need for a comprehensive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Personals . . .

work on special steels was apparent to Dr. Houdremont during his lectures in Aachen and Berlin, and the first step was to elaborate his lecture notes into a 550-page book (193) entitled "Einführung in die Sonderstahlkunde". The second edition, enlarged to 1035 pages, appeared in 1943 under the present title, "Handbuch der Sonderstahlkunde", and it was completely sold out within two years. The recent rapid advances in the art of manufacture and techniques of use of quality steel in all civilized countries required a complete review of the existing data, and information from a multitude of sources has been scrutinized and organized into this new edition, which is sure to be of great use to all American metallurgists who have a reading knowledge of the German language.

Robert B. Gordon has been appointed project engineer at the Sheldon Nuclear Facility of the Atomics International Div., North American Aviation, Inc., Canoga Park, Calif. In this position he will be in charge of component development for the 75-megawatt nuclear power reactor to be built for the Consumers Public Power District of Nebraska. Dr. Gordon was formerly associated with the Bettis Atomic Power Div., Westinghouse Electric Corp., as manager, core engineering department.

John E. Decker has been promoted to chief metallurgist of the Green River Steel Corp., Owensboro, Ky., a subsidiary of Jessop Steel Co. Mr. Decker joined Green River Steel in 1956 and last served as superintendent of the plant.

Kenneth M. Goldman has received a special award of $2000 for his achievement in solving one of the major problems in the design and development of the reactor for the U.S.S. Nautilus. Dr. Goldman received this award from Westinghouse Electric Corp. for his part in discovering a broad range of zirconium alloys in 1952. Associated with Westinghouse since 1951, he is presently supervisor of the corrosion and fuel element section of the A1W Project at the Naval Reactor's Facility, Arco, Idaho.

Personals . . .

F. J. Whitney, the current chairman of the Philadelphia Chapter, is now president of the Pennsylvania Mfg. Co. in Malvern, Pa. He was formerly affiliated with the Heintz Mfg. Co., Philadelphia.

Anthony Del Grosso has left his position as metallurgical engineer for the Atomic Power Development Assoc. in Detroit to take over the duties of staff metallurgist for the nuclear power division of Allis-Chalmers Mfg. Co., Milwaukee, Wis.

George F. Burditt has been appointed manager, steel mill equipment sales division, Wheelabrator Corp., Mishawaka, Ind. He has been with the company since 1947 and before his promotion was district manager of sales in Pittsburgh.

Claus G. Goetzel has resigned as vice-president and director of research for Sintercast Corp. of America, Yonkers, N.Y., to accept an appointment to the staff of the metallurgical engineering department of New York University as senior research scientist. He will continue to serve Sintercast as a consultant to the firm.

Richard H. Thompson has been added to the sales staff of Climax Molybdenum Co., New York., as manager, foundry sales. Mr. Thompson formerly held the same position with the American Car and Foundry Div., ACF Industries, Inc.

R. E. Nowlin has transferred from the gas turbine department of General Electric Co., Schenectady, to the small steam turbine department as materials engineer.

Donald A. Sandstedt has joined Michigan-Standard Alloy Casting Co. and Misco Fabricators, divisions of Michigan Industries Co., as manager of sales for Chicago, Milwaukee and Wisconsin areas, with headquarters in Chicago. Before coming to Michigan Industries, he was senior cost analyst at the Ford aviation plant in Chicago.

Edward J. Stofka, upon release from active duty with the U. S. Army Reserve, has taken a position as metallurgical engineer with the research and development group of the Carborundum Co., Niagara Falls, N.Y.

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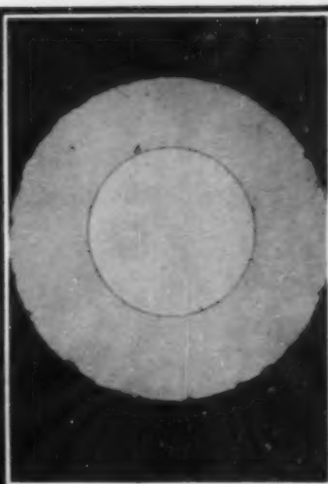
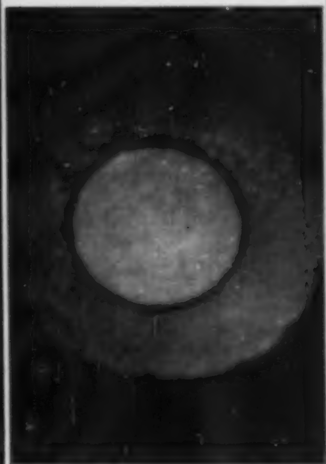


Actual photograph of gray-scale test transparency, shown unenhanced.



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Personals . . .

Fred H. Currie ⊕ has been appointed sales representative for Gulf States Tube Corp., Rosenberg, Tex., and Michigan Seamless Tube Co., South Lyon, Mich.

Ernest George Kendall ⊕ , after receiving his Ph.D. degree in metallurgical engineering at the University of Kentucky, has joined the staff of Atomics International Div., North American Aviation, Inc., Canoga Park, Calif.

Alfred Drain ⊕ has assumed new duties as chief engineer of the Canton Div. of E. W. Bliss Co. He has been with the division in various engineering capacities since 1951 and was project engineer before his recent promotion.

Marvin Feir ⊕ has left the Southington plant of Pratt & Whitney Aircraft, East Hartford, Conn., to become plant metallurgist at the Willimantic Cold Finishing Div., Jones & Laughlin Steel Co.

Gerald L. Moran ⊕ has been named general manager of the chemical and metallurgical division of Sylvania Electric Products, Inc., Towanda, Pa. Mr. Moran has been division chief engineer since 1954.

Thomas M. Kaneko ⊕ resigned his post as metallurgist at the Metals Research Laboratories of Union Carbide Co., Niagara Falls, N.Y., to accept a position as metallurgist in the metals group of the research division, U. S. Industrial Chemicals Co., Cincinnati, Ohio.

Four ⊕ members have received appointments to key positions in the metallurgical department of the Babcock & Wilcox Co.'s tubular products division. **John F. Beck** ⊕ is now metallurgist supervisor of technical service, handling liaison on technical matters between the tubular products division and its customers. **Clark P. Church** ⊕ has become metallurgist supervisor of process development, with responsibility for supervising development of mill processes relating to new materials and methods. **John F. Ewing** ⊕ now supervises research studies and alloy research as metallurgist supervisor of research, while **Thomas M. Krebs** ⊕ is now metallurgist supervisor of customer service.

Personals . . .

Peter Dowbor has been assigned to the physical testing section of Allis-Chalmers Mfg. Co.'s research division in Milwaukee, Wis., as a metallurgist. A metallurgical engineering graduate of Illinois Institute of Technology, Mr. Dowbor has completed Allis-Chalmers' training course for graduate engineers.

George E. Kuck has been named manager of the Metallurgical Instruments Div. of Intercontinental Electronics Corp., Mineola, N.Y. Mr. Kuck had acted until recently as manager, materials laboratory, of Avco Mfg. Co.'s Lycoming Div.

Floyd R. Anderson, chief metallurgist of the Denver division of the Gardner-Denver Co., Quincy, Ill., has been named assistant manager of the division. He started his career with the company in 1925 as a laboratory assistant for the Denver Rock Drill Mfg. Co., which later merged with the Gardner Governor Co. as Gardner-Denver Co. Succeeding Mr. Anderson as chief metallurgist is **Richard F. Schaffer**. He joined Gardner-Denver in 1940 as assistant metallurgist, after graduation from the Colorado School of Mines.

Edward O. Falberg has been appointed manager of the Greensburg, Ind., plant of the Bohn Aluminum & Brass Corp., Detroit. Mr. Falberg has been associated with the company since 1950, and prior to his new post was plant manager of three of Bohn's Detroit plants.

Sheldon Weinig, formerly assistant professor of metallurgy, college of engineering, New York University, has been elected president of the newly formed Materials Research Corp., Yonkers, N.Y. The new corporation will provide research and development services for industry and government.

Martin L. Slawsky has been appointed development engineer, precision pilot plant, for the applied research and development laboratory of General Electric Co.'s foundry department in Schenectady. Mr. Slawsky has been with the company since 1955 and before that was employed by the Watervliet Arsenal, Watervliet, N.Y., as a metallurgist in the metals processing section.

Personals . . .

Paul E. Sample has joined the film department of E. I. du Pont de Nemours & Co., Inc., Clinton, Iowa, as a research engineer. Dr. Sample, a graduate of Illinois Institute of Technology, received his M.S. degree from West Virginia University and last June completed work for his Ph.D. degree.

David W. Mitchell has joined the Foote Mineral Co.'s research and development department as manager of minerals research at the Kings Mountain research laboratories. Dr. Mitchell served as associate professor of metallurgy at the University of California for twelve years.

Robert W. Lindsay resigned as professor of metallurgy at Pennsylvania State University, after 14 years on the faculty. He has joined the research and development organization of Crucible Steel Co. of America, Pittsburgh, as supervisor of research, constructional alloys, and will be concerned with carbon and alloy-type constructional steels.

A. M. Aksoy is manager of the new applied research laboratory of Crucible Steel Co. of America, located at the company's Sanderson-Halcomb Works in Syracuse, N.Y. For the past three years, Dr. Aksoy had been chief metallurgist for Vacuum Metals Corp., Syracuse, an operating division of Sanderson-Halcomb Works. Before joining Vacuum Metals in 1954, he was an associate professor of metallurgy on the faculty of Drexel Institute of Technology, Philadelphia.

Henry A. Domian has resigned his U.S. Air Force commission to accept a position as research metallurgist with the Ford Scientific Laboratory, Dearborn, Mich.

Paul D. Frost, chief of the light metals division at Battelle Memorial Institute, Columbus, Ohio, was awarded the 1957 Metal Treating Institute Achievement Award for an article and lecture based on studies concerning heat treatment of titanium, which were conducted under his supervision. These studies formed an integral part of the research which culminated in the discovery of methods for heat treating titanium alloys.

Personals . . .

Harry B. Nicholson has moved from the Ashland, Ohio, works of Armco Steel Corp. to the company's general offices in Middletown, Ohio, as assistant to the vice-president of operations of the Armco Div. Mr. Nicholson joined the company at the Ashland works in 1924 and was named general superintendent of the works in 1949, remaining in this post until his new appointment.

John James Knox has taken a position as purchasing director of Reading Tube Corp., Reading, Pa., and its subsidiaries, Reading Metals Refining Corp. and Mackenzie Walton Corp. of Pawtucket, R.I. Before accepting this post, he was purchasing director of Hubeny Brothers, Roselle, N.J., and Metals Disintegrating Co., Elizabeth, N.J.

Ernest R. Howard has become a member of the Truflex thermostat metals sales and engineering staff of the General Plate Div., Metals & Controls Corp., Attleboro, Mass. He was previously associated with Wade Electric Products, Sturgis, Mich.

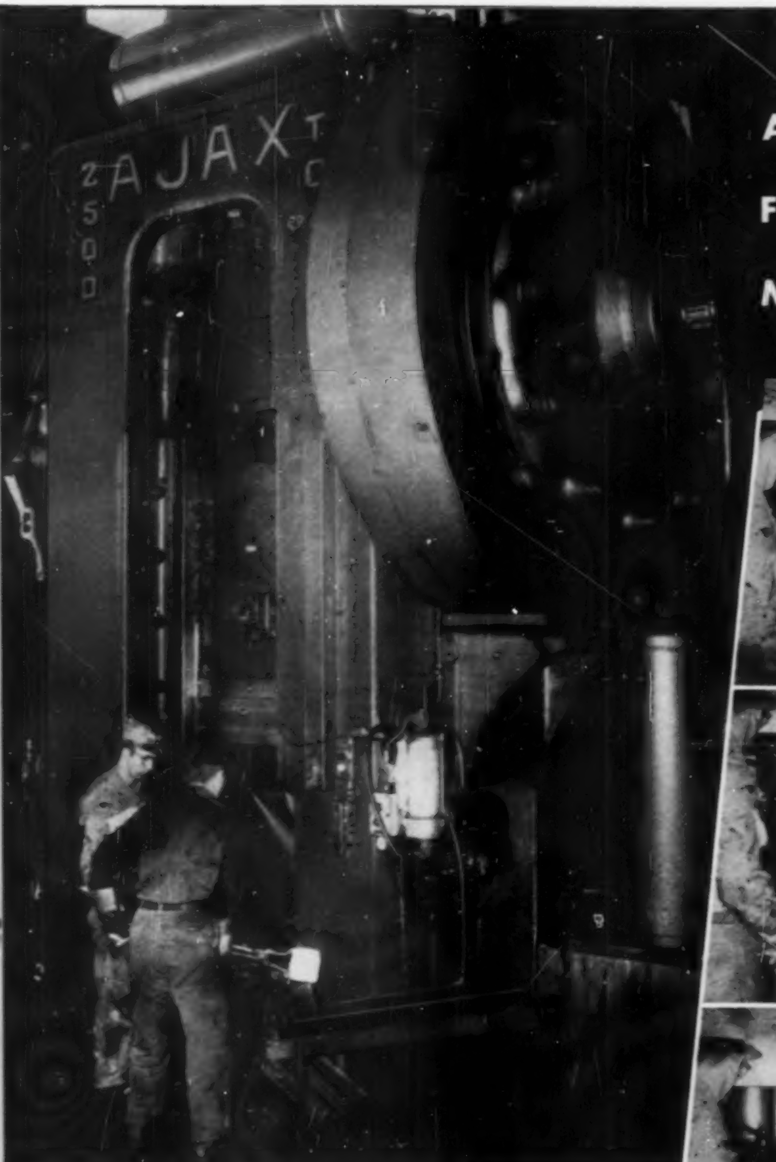
James H. Peacock has returned to the Duriron Co., Inc., Dayton, Ohio, after his release from active duty with the armed forces.

W. L. Hawks has assumed new responsibilities as district sales manager of the San Francisco office of Pacific Scientific Co. In his new capacity, he will coordinate sales and service operations for Pacific's furnace division and aero division. Mr. Hawks was previously associated with Pacific's Los Angeles office.

E. G. Jennings has started his own consulting and agent business, E. G. Jennings, Ltd., in Toronto, Ont., specializing in the rarer metals and all metallurgical problems in the nonferrous metals field.

H. F. Krueger is now assistant vice-president of the Murray Ohio Mfg. Co., Nashville, Tenn.

Burton Reese is currently branch manager of the Boston sales branch of Crucible Steel Co. of America, which distributes steels to the New England states. Before his promotion, Mr. Reese was assistant branch manager.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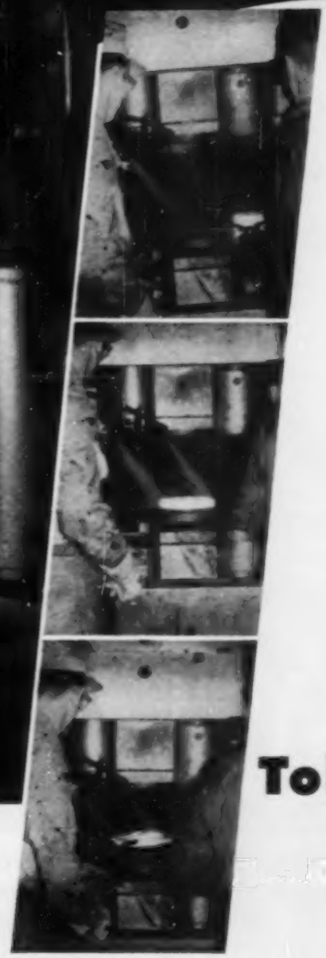


Personals . . .

Ross L. Bryson has transferred from U.S. Steel Corp.'s Applied Research Laboratory in Monroeville, Pa., to the Gary, Ind., steel works as development metallurgist.

Harold W. Lownie, Jr., chief of the process metallurgy research division at Battelle Memorial Institute, Columbus, Ohio, has been elected chairman of the gray iron foundry division of the American Foundrymen's Society.

E. H. McIntyre, formerly laboratory supervisor for Sorel Industries, is presently engaged by Canadian Steel Wheel, Ltd., Montreal, as an engineer.

Burton S. Payne, Jr., has been chosen to head the metallurgical research and development group in the research division of the Pfaudler Co., Rochester, N.Y. A graduate of Rensselaer Polytechnic Institute, Mr. Payne joined Pfaudler in 1956 as a metallurgist.

Henry C. Armstrong is studying international business administration in Geneva, Switzerland, at the Centre d'Etudes Industrielles, a school organized by the Aluminum Co. of Canada, Ltd., Ottawa, Ont., ten years ago. Mr. Armstrong, a member of the sales staff of Aluminum Co. of Canada, will attend the school for a year on a company scholarship to learn more about European business.

Ernest G. Rieker, Jr., is now chief engineer for Precision Grinding Wheel Co., Inc., Abington, Pa.

James P. McNally has taken a position as product manager of the newly opened Philadelphia plant of the Arcflux Corp., a subsidiary of the Arcos Co. Until taking over his new assignment, he was superintendent of the Union Tank Car Co., Chicago.

W. A. Hammer has joined the Mid-Continent Div. of Earle M. Jorgensen Co., Dallas, Tex., as a metallurgical engineer.

Raymond J. Zale has accepted an appointment as general sales manager of the Vulcan Crucible Steel Div., H. K. Porter Co., Inc., Aliquippa, Pa. Before joining Vulcan Crucible Steel, Mr. Zale was assistant steel sales manager with Firth-Sterling, Inc., Pittsburgh.

Personals . . .

John E. Stoll is now employed as a welding engineer in the guided missile field with the Hicks Corp., Boston, Mass. Until recently Mr. Stoll was on the staff of the Newark Development Laboratory of the Linde Co.

Henry A. Roemer III was recently appointed sales representative in the Chicago district sales office of Sharon Steel Corp., Sharon, Pa. Mr. Roemer was formerly a sales trainee at the company's Roemer works in Farrell, Pa.

L. H. Grenell has accepted a position with Stolle Corp., Sidney, Ohio, as assistant to the president for development.

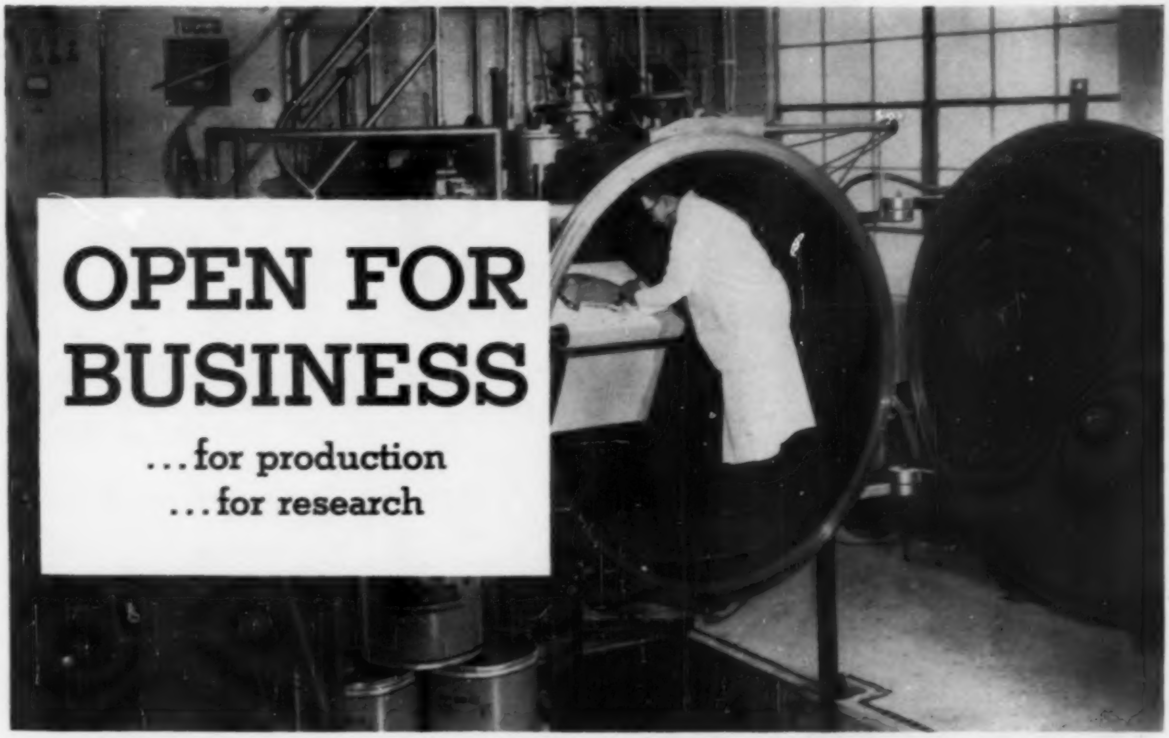
J. G. Wortley, until recently general manager, sales, of the Kenilworth, N.J., plant of the strip steel division, Jones & Laughlin Steel Corp., is now general manager of the plant. He has been employed at the Kenilworth plant for the past eight years and before that was manager of stainless steel products for Benedict-Miller Steel Co.

Robert N. Libsch has been promoted from project engineer to chief metallurgist of the American Bosch Div., American Bosch Arma Corp., Springfield, Mass.

S. L. Gertsman, chief of the physical metallurgical division, Department of Mines and Surveys, Ottawa, Ont., has received the first Award of Merit of the Steel Castings Institute of Canada. This award will be presented in recognition of outstanding service to the steel castings industry in Canada.

Richard D. Potter, a member of the Navy Dept.'s Bureau of Ordnance has moved to the U.S. Naval Powder Factory at Indian Head, Md., as director of the production and production engineering department. He was formerly head of the materials engineering division, U.S. Naval Ordnance Test Station, China Lake, Calif.

D. Gardner Foulke was awarded the Carl E. Heussner Award at the American Electroplaters' Society's annual meeting in Montreal last year for his paper on current distribution on microprofiles.



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METALLURGICAL SPECIALISTS

Personals . . .

T. S. Laurie has been appointed resident representative for Crucible Steel Co. of America, covering San Diego County and Imperial County in California.

Gerald W. Hulit has joined Austenal, Inc. He was formerly a metallurgist at Wright Aeronautical Corp., Wood-Ridge, N.J.

S. L. Withrow has been transferred from the Los Angeles office of Klem Chemicals, Inc., to the Detroit office. The transfer involves a promotion to vice-president.

Anthony F. Fortuna has been transferred back to the main plant of the Radioplane Co., a division of Northrup Aircraft, Inc., as manager of inspection.

John L. Filson, who left the Rheem Mfg. Co. two years ago, has established a consulting business in California. He recently completed an assignment for the Rudisill Foundry Co.'s shell division at Sylacauga, Ala., and is now associated with Al's Mfg. Co., Alvarado, Calif.

Felix Kremp has been appointed vice-president of Braeburn Alloy Steel Corp., Braeburn, Pa. Mr. Kremp will assume responsibility for sales coordination and market research.

E. B. Pool, research engineer for Edward Valves, Inc., East Chicago, Ind., since 1951, has been promoted to chief research engineer. At the same time, **Harold N. Meyers** has been appointed research metallurgist for the company. Mr. Meyers, a former chairman of the Western Michigan Chapter, was manager of engineering for West Michigan Steel Foundry Co., Muskegon, Mich., before taking over his new job.

Frank W. Schaller, formerly a research engineer at the Ford Scientific Laboratory, Dearborn, Mich., is now a research assistant at Case Institute of Technology, working toward an advanced degree in metallurgy.

L. W. Eastwood is currently research manager of the aluminum division for Olin-Mathieson Corp., New York.

Digests of Important Articles

Electric Spark Machining

Digest of "Some Observations With the Electric Spark Machining Process", by G. R. Wilms and J. B. Wade, *Metallurgia*, Vol. 54, December 1956, p. 263-268.

RESEARCH carried out in Australia on the spark machining of annealed samples of chromium, aluminum, iron, and antimony has revealed interesting information on the mechanism of metal removal and effects on metal surfaces. Essentially, conclusions are that metal removal is by thermal rather than by purely mechanical means, and that both deformation and cracking of the surfaces occur.

Spark machining equipment for the tests incorporated a simple relaxation circuit for generation of the required train of spark discharges. A 3/16-in. diameter brass rod was used as the cathode tool and this, together with the anode workpiece, was placed in a small tank. The dielectric was kerosene, circulated continuously across the spark gap. To maintain the correct gap (0.0003 to 0.0015 in.), the position of the tool electrode was servocontrolled from the voltage across the electrodes by comparison with a reference voltage. Standard operating conditions were established at 120 v., 1 amp., and 25 microfarad capacitance.

Chromium, aluminum, iron and antimony specimens of high purity were employed. They were polished electrolytically, except for antimony which could not be so finished and was polished mechanically.

The spark-formed impressions resembled crater-like depressions, similar to shot-blasted surfaces. Chromium and iron were smoother, yet less bright and reflective, than aluminum and antimony. Microscopic examination revealed small globules of metal adhering to the surface, untypical of mechanical fracture and thus suggesting fusion.

All four metals showed plastic deformation around the formed holes, most markedly in respect to aluminum on which slip lines could be observed some 0.050 in. from the edge. Similar lines were visible 0.050 in. from the edge in chromium specimens and 0.010 in. from the edge in iron specimens.

An opinion that this deformation might have been caused by bumping of the tool as a result of the servocontrol producing hunting was disproved by running a sample with manual control of the tool to avoid contact. The metal was still deformed.

Cracks were observed around the edge of the hole in chromium specimens; a network of cracks was found within the hole. No cracks were found in aluminum or iron.

Residues from each specimen were collected from the dielectric by filtering and drying; they were then examined microscopically. All metallic particles were found to be globular in shape, with a considerable variation in size, suggesting that the metal had either melted, or had vaporized and condensed in the surrounding dielectric.

All this evidence points to fusion during the spark machining process, rather than mechanical fracture of particles – a thesis that some investigators have held. Deformation and surface cracking from thermal stress does not detract from the practical value of the process since these defects can be removed by a finishing operation.

Spark machining is a most attractive technique for shaping extremely hard metals and alloys, and for forming complex holes in softer metals or electroconductive materials.

ARTHUR H. ALLEN

Joints and Piping for 5600-Psi. Steam

Digest of "Metallurgical Considerations of Main Steam Piping for High-Temperature High-Pressure Service," by Harry Blumberg, presented at Power and Metals Engineering Divisions of American Society of Mechanical Engineers Annual Meeting in New York City, Nov. 25 to 30, 1956. Paper No. 56-A-157, 24 p.

THE STEAM POWER industry did not require materials to operate above 900° F. until 1940, and by that time some 15 years of service experience had accumulated in that range of temperatures in the petroleum refineries. Several ferritic steels were utilized satisfactorily in services up to 1050° F. max. For higher temperatures piping made of A.I.S.I. Type 347 (austenitic 18-12 Cr-Ni stainless stabilized with columbium) and Type 316 (austenitic 16-13-2 Cr-Ni-Mo) have been used, the former since 1949 and the latter since 1952. The 1951 edition of the Boiler Code sets maximum allowable stresses of 13,100 psi. at 1050° F. for both these types, 5000 psi. at 1200° F. for Type 347, and 6800 psi. at 1200° F. for Type 316.

In approaching a decision as to piping for the Eddystone Station of the Philadelphia Electric Co., which will operate at 1200° F. and 5600 psi., the most severe in this country, a study was made of available piping from several angles. In view of the great wall thicknesses required of the piping designed according to Boiler Code allowables, the "superstrength" alloys were reviewed. There seemed to be three alloys worthy of consideration, namely 15-15 N, 17-14 CuMo and N 155, with allowable stress at 1200° F. estimated to be 11,400, 12,000 and

Joints and Piping . . .

10,500 psi. respectively. Their analyses are as follows:

	15-15 N	17-14 CuMo	N 155
Cr	15	16	21
Ni	15	14	20
Mo	1.5	2.5	3
Co	–	–	20
W	1.5	–	2.5
Cu	–	3	–
Cb	1.0	0.5	1.0
Ti	–	0.3	–
C	< 0.15	0.12	0.3
N	< 0.15	–	–

Even though these seemed to have satisfactory properties and weldability, none of them had been recognized by the A.S.M.E. Boiler Code nor used in large piping systems; consequently actual choice for Eddystone was limited to the stainless Types 347 and 316. Nevertheless the 15-15 N, 17-14 CuMo and N 155 were included in the investigation of welding processes for 11½-in. outside diameter pipe with walls 3 in. thick. Weldability was studied – by that meaning visual observation of each head, shrinkage measurements, and inspection by X-rays and by dye penetrant. Properties of the joints at room temperature (both as welded and as aged 1000 hr. and 10,000 hr. at 1300° F.) were determined as follows: (*a*) weld joint side bend tests; (*b*) notched-bar impact tests in weld, heat affected zone, and base metal, and hardness explorations on cross sections; (*c*) at elevated temperature it was attempted to induce weld cracking by thermal cycling; stress-rupture tests were also made in welded and aged conditions; (*d*) macro and microsections were examined.

From the results it was concluded that Types 347 and 316 can be welded satisfactorily under restraint in 3-in. pipe walls with either a matching electrode or the 16-8-2 composition, as judged by visual, penetrant dye and X-ray examinations performed at several stages during welding. Electrodes of 16-8-2 Cr-Ni-Mo type deposit welds with distinctly higher impact values in both Type 347 and 316 piping metals than welds made in each with a matching electrode, and deteriorate less after 1000-hr. aging at 1300° F. than the matching welds.

(*Continued on page* 142)

Joints and Piping . . .

Of the matching-electrode deposits, Type 316 weld deposits are definitely tougher than the Type 347 welds.

Thus, Type 316 base metal joined with 16-8-2 deposit possesses the most satisfactory properties. (For other experience with this weld metal see "Cracking Tendency in Heavy High-Temperature Steam Piping" by Henry M. Soldan and Charles R. Mayne, *Metal Progress*, March 1957, p. 78.) This selection is warranted by other factors:

1. Type 316 has the Boiler Code's highest allowable stress at 1200° F.

2. Much fabrication and plant experience is available as background.

3. Piping is available as seamless tubing or from forgings, turned and bored.

4. Tendency toward weld cracks (either microscopic or macroscopic) is probably a minimum – possibly will be nonexistent with the 16-8-2 electrode.

Purchase specifications for Eddystone main steam piping include references to control of hot working temperatures, grain size and weld-thermal cycle hot ductility tests. Although these will not constitute a basis for rejection, it is expected that they will result in additional controls in steel manufacturing and conversion to piping, from which an improvement in materials quality will result. E. E. Thum

Thorium-Zirconium and Thorium-Hafnium Phase Diagrams

Digest of "Thorium-Zirconium and Thorium-Hafnium Alloy Systems", by E. D. Gibson, B. A. Loomis and O. N. Carlson, Preprint No. 24, 1957.

This paper describes a complete diagram for the thorium-zirconium system and a proposed diagram for the thorium-hafnium system. The alloys were prepared by arc melting using thorium sponge, crystal bar zirconium and crystal bar hafnium. The phase changes and reactions were investigated by electrical resistance measurements, differential cooling curves, X-ray diffraction studies and microscopic examination. Extensive use was made of high-temperature X-ray methods in studying the Th-Zr system.

The Th-Zr system has (*a*) an azeotope at 2460° F. at 25% Zr by weight; (*b*) a monotectoid at 1670° F. at 25% Zr by weight with a solid immiscibility loop lying above the 1670° F. horizontal extending from 25 to 37% Zr by weight; (*c*) a eutectoid at 1200° F. at 69% Zr by weight; (*d*) a solubility of Zr in Th of about 5.5, 6.4, and 2% by weight at 1830° F., 1670° F. and room temperature, respectively; (*e*) a solubility of Th in Zr of 0.5% by weight or less; (*f*) no intermediate phases.

The Th-Zr diagram presented is very similar in appearance to that previously published in "Compilation of U.S. and U.K. Uranium and Thorium Constitutional Diagrams," BMI-1000, Technical Information Service, Atomic Energy Commission, Oak Ridge, Tenn. The major differences are in the location of the monotectoid (at about 13% weight in the earlier diagram) and in the delineation of the solid immiscibility loop.

The proposed Th-Hf system has (*a*) a eutectic at 2640° F. at 25.7% Hf by weight; (*b*) a eutectoid at

Phase Diagrams . . .

2360° F. at 8.9% Hf by weight; (*c*) an inverse peritectic postulated at 2910° F. at 96% Hf by weight; (*d*) β-Th dissolves a maximum of about 13% Hf by weight at 2460° F., (*e*) α-Th dissolves a maximum of about 6 and 5% by weight at 2360° F. and room temperature respectively; (*f*) α-Hf dissolves about 2% Th by weight at temperatures between 2370 and 2910° F. with insignificant solubility at room temperature; (*g*) no intermediate phases.

A cursory comparison indicates that these two systems are quite dissimilar despite an anticipated analogous alloying behavior of Zr and Hf because of their marked chemical and physical similarity. Closer examination, however, reveals that there are similarities in the two systems since both show minima in the melting curves, depression of allotropic transformation of thorium (by either a monotectic or eutectoid) and limited terminal solid solubility in α-Th. If the solid immiscibility loop in the Th-Zr system could be expanded to intersect the solidus, the two systems would appear quite similar. The principal differences, therefore, are in the size of the solid immiscibility loop and the relative stability of the hexagonal α-Zr and α-Hf phases.

Difference in solid solubility is probably due to a difference in atomic size. Zr and Hf have approximately the same atomic radius at room temperature, but there is evidence indicating that Hf has an appreciably smaller atomic radius than Zr at high temperature. If Hume-Rothery's rule of 15% limit of radius difference is applied, the difference in the extent of solid solubility of the high-temperature thorium base phases can be explained.

The relative stability of the hexagonal α-Zr and α-Hf phases is due to the difference in allotropic transformation temperatures. The markedly higher transformation temperature of Hf opposes the stabilization of β-Hf by eutectoid formation (as occurs in the Th-Zr system) and favors the somewhat analogous inverse peritectic reaction that is found in the Th-Hf system.

C. O. SMITH

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Rotary Oxygen Steelmaking

Digest of "Stora's Kal-Do Rotary Oxygen Steelmaking Process," by Bo Kalling and Folke Johansson, *Blast Furnace and Steel Plant*, Vol. 45, February 1957, p. 200-203.

Most steelmaking converters used to decarburize liquid blast furnace iron with air or oxygen operate in a stationary, upright position. However, the Domnarvet Steel Works has used a unique, rotary 30-ton converter in production since May 1956. This "Kal-do" furnace resembles a conventional bessemer converter in shape but is tilted so that the surface of the bath is inclined at an angle of only about 20° from the side of the vessel. For charging, of course, the converter is tilted to a nearly vertical position. The oxygen jet is introduced into the furnace through the central opening at one end of the furnace which also serves for charging and as the outlet for exhaust gases. It is possible to direct the jet into the bath of metal or to introduce oxygen only above the surface of the slag. By combining changes in rotational speeds and methods of introducing oxygen the kinetics of the chemical reactions can be controlled. The purposes of rotating the furnace are (*a*) to insure better stirring, (*b*) to reduce temperature gradients, and (*c*) to minimize losses of iron caused by vaporization.

The Kal-do rotary oxygen converter has been operating on irons of the type used in Europe with the basic bessemer process. A typical high-phosphorus pig iron contains about 3.5% C, 0.5% Mn, 1.9% P, 0.06% S, 0.25% Si, and 0.1% V. The gas fed to the converter contains about 97% oxygen; the consumption ranges around 2400 cu. ft. per ton of pig iron. Because the heat economy of the furnace is good, ore or scrap additions can be used to cool the bath. Usually the amount of fine sintered ore added to the vessel corresponds to about 14% of the charge weight. This figure suggests that scrap additions amounting to about 40% of the weight of hot metal could be substituted for ore. This point has not been investigated because facilities suitable for handling such

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The above furnace, equipped with 7" O.D. refractory compression rolls anneals hot rolled and cold reduced straight chrome and crome-nickel stainless sheets up to 2100°F at the rate of five (5) tons per hour.

The success in utilizing the Drever Refractory Compression Roll in annealing stainless steels has been attributed to the roll strength and its resistance to pickup which completely eliminates the necessity of using rider sheets. The refractory rolls are prestressed and consist of silicon carbide sections retained by spring loaded alloy ends to allow for expansion and to provide axial forces to insure structural stability under rated load. Furnaces have been installed with roll sizes varying from 4½" O.D. x 20½" long to 14" O.D. x 14'-6" long.

In addition to annealing stainless steel sheets, plates, bars and tubing, materials have been successfully heat treated at 2300°F. Avail yourself of the experience of Dreyer Company engineers in solving your stainless steel annealing problems.

DREVER COMPANY

RED LION ROAD and PHILMONT AVE., BETHAYRES, PA.

Steelmaking . . .

large scrap additions are not available at Domnarvet. Lime additions to the vessel range around 13%, the amount normally used for basic bessemer operations.

Ordinarily the Kal-do converter rotates at a speed of 30 rpm. The furnace lining of tar dolomite lasts about 50 heats and the life is said to be independent of rotational speed. In other terms, this amounts to about ¼ in. of lining per heat or 45 lb. of dolomite per ton of steel. The erosion of the lining contributes about 4% MgO to the slag. Ordinarily a two-slag process is used to treat basic bessemer iron. The first slag, containing about 3.0% Fe and 22% P_2O_5, is removed about 20 min. after the start of the blow. The total blowing time is ordinarily 35 to 40 min. and the final slag contains about 14% Fe. The yield of molten metal is about 92% of the iron charged. This high iron recovery confirms the statement that spitting and boiling are not a problem.

Steels with impurity contents as low as 0.002% N, 0.010% S and 0.005% P are produced by the rotary oxygen steelmaking process. In the early stages of blowing, phosphorus is oxidized proportionally faster than carbon so it is often possible to stop the reaction when the desired carbon content is reached. Thus steels of various grades can be produced by catching the carbon content at the desired level, or by recarburizing. The steels, of course, have mechanical properties comparable to those with similar compositions made in other types of melting units. The low metalloid contents are desirable in steels for welding, deep drawing or other specialized applications.

F. W. Boulger

Creep Properties of 18-8 Stainless Steel

Digest of "Some Creep Properties of 18-8 Stainless Steels at Room Temperature, 250° C., 400° C., and 550° C.", by L. W. Larke and R. A. Whittaker, R.A.E. Tech. Note Met. 240, Ministry of Supply, London, March 1956, 14 p.

Until recently there has been little interest in creep properties of high-temperature materials for temperatures below 570° F. and for times below 300 hr. This work had two purposes—to determine these creep properties, and to explore the effect of previous cold work on subsequent creep.

The material was 18-8 stainless steel in ¾-in. diameter bars. Test pieces had a gage length of 2 in. and a cross-sectional area of 0.1 sq. in. In order to insure complete softness, the steel was annealed at 1800° F. and quenched in cold water. The diamond pyramid hardness was reduced from 223 to about 176, indicating that the rod had been hardened in a straightening process.

Employing high-sensitivity techniques, constant load creep tests were made at the prescribed temperatures. Perhaps to reduce the number of tests at varying stress levels required for a complete program, stresses for creep tests were selected from short-time stress-strain tensile data which were equivalent

Creep of 18-8 . . .

to 0.01%, 0.1% and 0.2% proof stress at each temperature.

The method did not have much success; apparently no attempt was made to measure deformation rate during the early minutes of the test. In all tests there was a relatively large deformation on loading, and the creep-strain time curves at points below 1020° F. were the almost straight lines of secondary creep. At 1020° F. the authors report that tertiary creep began after 100 hr. To obtain the information sought, it is necessary to report rate of deformation during the loading stage, to explore temperatures intermediate between those reported, and to test for times longer than 500 hr. The authors were aware that certain anomalies existed regarding stresses to produce given strains, and that these were probably influenced by the method of applying the load.

Test pieces which had been prestrained up to 1.0% proof stress at room temperature were tested. All showed improved creep properties at 480° F. Total deformation after 300 hr. was reduced from 0.07% to 0.02% for the 0.05% proof stress. The deformation and work hardening, normally taking place in the creep test on a soft material, were accomplished by the prestrain so that total deformation during the test were reduced. This is an important discovery and justifies further work to define limits of deformation and temperatures.

Tests indicate a decrease in elastic modulus from 29 to 22 $\times$ 10⁶ psi. as the temperature rises from room temperature to 1020° F. The conditions of the tests did not permit the preparation of traditional design data, but there is little difference in rate of strain up to 500 hr. for loads of 0.2% proof stress up to 750° F. There is evidence that prestraining reduced the creep deformation at 480° F.

JOSIAH W. JONES

Electric Smelting of Ores

Digest of "Experimental Electric Smelting of Ores and Related Materials, at the Department of Mines and Technical Surveys, Ottawa", by G. E. Viens, R. A. Campbell and R. R. Rogers, *Canadian Mining and Metallurgical Bulletin*, Vol. 50, February 1957, p. 70-77.

A THREE-PHASE, continuously operated, 250-kva. electric furnace has been installed at the Mines Branch for the experimental smelting of ores and their byproducts. With this furnace and accessory equipment it is possible to (*a*) determine the feasibility of a smelting process from a chemical standpoint, (*b*) obtain qualitative data regarding the most suitable smelting technique and the nature of the products, (*c*) obtain preliminary data regarding the cost of power and electrodes, and (*d*) determine the advisability of continuing the investigation of the process on a large and expensive plant scale.

Up to the present the equipment has been used for the experimental smelting of iron ore, manganese-iron ore, titanium ore, nickel ore, chromium-iron ore, "mill tailings" from the asbestos industry, "red mud" from the aluminum industry, and blast furnace flue dust.

The results of the experiments clearly show the value of electric smelting for the treatment of these materials. The furnace used is of the Electromelt type and, though much smaller than commercial furnaces, has proved satisfactory for


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Smelting of Ores . . .

preliminary work. It is operated continuously, the products being removed at suitable intervals. A week's run is the usual thing. Metal taps may be as large as 600 lb. and slag taps 1200 lb.

The furnace consists of a rectangular steel shell 92 × 80 × 50 in. deep. These are inside dimensions. Linings used are of acid, basic, neutral or carbon refractories. There are three tap holes located at different heights. Usually the highest is used for tapping slag, the middle one for metal, and the bottom one for cleaning out the furnace after the run. Eleven thermocouples are placed permanently in the hearth and provide accurate temperature records. The three electrodes, arranged in line, are either $5\frac{1}{8}$-in. graphite or 8-in. diameter carbon. The furnace is operated with or without a roof. The heating, conducted by "slag resistance" or "arc resistance" can be operated under open bath smelting conditions—that is, when the molten slag surrounding the electrodes is visible—or under dry top smelting conditions by maintaining a layer of unsmelted charge above the molten slag. A number of power settings are available, having voltages ranging from 58 to 320 v. and current settings as high as 1604 amp. per phase. The automatic control is of the "balanced beam" type.

A description of the smelting investigations follows:

Low-carbon iron was produced from magnetic iron ore having the typical analysis, 56.5% Fe, 11.5% SiO_2, 3.9% Al_2O_3, 0.2% CaO, with a trace of MgO. 20,200 lb. of ore yielded 8600 lb. of low-carbon iron and 8800 lb. of slag. Operation lasted 136 hr. and consumed 4540 kw-hr. per ton of iron. Carbon content of iron averaged 1.8%.

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Smelting of Ores . . .

iron produced was of good grade, the average analysis being 4.2% C, 1.9% Si, 1.3% Mn, 0.026% S, 0.021% P, 92.5% Fe.

Ferronickel Smelted From Nickel Ore – The composition of this ore was 2.8 to 3.1% Ni, 11.3 to 13.7% Fe, 0.06 to 0.09% Co, 0.05 to 0.12% S, 0.005 to 0.011% P, 38.1 to 41.7% SiO_2, 2.4 to 4.4% Al_2O_3, 20.5 to 31.2% MgO. The nickel content of the final slag varied between 0.06 and 0.52%, the average being 0.19%. The highest nickel losses to the slag took place during the final smelting period, when a metal with a higher nickel content was produced in the electric furnace.

On the basis of these experiments it is concluded that ferronickel containing up to 43% nickel may be obtained by smelting ore of this type under conditions of selective reduction, the loss of nickel to the slag increasing somewhat as the nickel content of the ferronickel is increased.

Asbestos mill tailings, an industrial byproduct containing 0.26% Ni, 0.12% Cr, 5.30% Fe, 42% SiO_2, 1.9% Al_2O_3, 49% MgO, were smelted using the selective reduction technique. 36,000 lb. of calcined tailings yielded 200 lb. of ferronickel in 100 hr., consuming 1180 kw-hr. per ton of tailings.

Red mud, a byproduct of bauxite purification, was smelted in a 60-kva. furnace. Preliminary work yielded a considerable portion of the iron; however, the iron produced had a high phosphorus content.

Blast furnace flue dust was smelted to produce iron. Little or no loss occured due to dusting and the test was considered satisfactory in every way. Lime was used to agglomerate the fines which were pelletized for smelting.

HAROLD J. ROAST

Tramp Elements

Review of "Effect of Residual Elements on the Properties of Metals", ⊜ Educational Lecture Series, 1956. Red cloth binding, 217 p., 6¼ × 9¼ in., American Society for Metals, 7301 Euclid Ave., Cleveland 3, Ohio. $4.00.

THIS BOOK contains authoritative statements by five expert metallurgists on the effects of trace elements in steels and the common nonferrous alloys as well as many of the metals which have recently sprung into prominence. It is known that effects vary widely. It has been said that if the ordinary product of iron ore smelting were pure iron, the first thing the engineer would do would be to "contaminate" it with other elements in order to make it useful. Just as frequently, impurities have unwanted effects. The lectures here reported review the fundamental considerations and report the effects of residual elements on aluminum, magnesium, copper, nickel, steel, semiconductors, titanium, zirconium, molybdenum and chromium. Both mechanical properties and crystal growth and, in turn, strength and ductility of these metals are strongly influenced by small quantities of trace elements, according to Earl R. Parker, professor of metallurgy at the University of California.

In fact, writes F. H. Rhines, Alcoa professor of light metals at Carnegie Institute of Technology, Pittsburgh, the behavior of pure metals would be so strange that drastic alterations in fabricating procedures would often be required. Physical properties would be so different as to unfit these metals for some of their ordinary uses. He discusses the

Tramp Elements . . .

impurities in aluminum and their effect on electrical conductivity, mechanical properties and embrittlement. He also deals with magnesium, copper and nickel and the effect of impurities on these metals.

All of the elements found in finished steel which have not been added intentionally are "residual elements". They have varying effects on properties, writes James W. Halley, assistant superintendent of the research and development department, Inland Steel Co., East Chicago. While some of these residual elements are almost completely removed, the leftovers may be essential to the proper functioning of the steel or, on the other hand, may be detrimental to some desired properties. They affect ductility at elevated temperatures, corrosion resistance, annealed hardness, hardenability, strain aging and grain size control. In all, only 15 elements are important residuals in steel, and of these sulphur, phosphorus and copper are by far the most important – also the best known.

Semiconductors, so important in the growing electronics industry, are also affected by impurities, according to J. H. Scaff of the Bell Telephone Laboratories, Murray Hill, N.J. He describes the important role of impurities and impurity distribution in semiconductor devices and the chemical and metallurgical procedures employed to obtain the desired distribution of atoms in the solid, highly purified metal.

Titanium, zirconium, molybdenum and chromium have a bright future in metallurgical use and the commercial problems consist in great measure of recognizing and controlling the effects of minor contaminants. So writes D. J. McPherson, assistant manager of the metals research department of Armour Research Foundation, Chicago, in the concluding chapter of this book. Mr. McPherson discusses the impurity effects on physical and mechanical properties, stress-strain behavior, tensile, impact and fatigue properties and welding.

The student desiring to supplement his reading will find numerous references to recent periodical literature – which generally is several months, even years, ahead of textbooks.

Ernest Pessel

Gas Turbine Research in Australia

Digest of "Aeronautical Development in Australia", by L. P. Coombes, *Journal* of the Royal Aeronautical Society, London, Vol. 61, February 1957, p. 69-102; digested in *The Engineer*, Vol. 202, Nov. 23, 1956, p. 741-742.

The major problem in the early development of the gas turbine was a supply of materials for turbine blades with sufficient design strength at high temperature (1112° F.). From those early engines of a few thousand pounds thrust, the present types with 25,000 lb. thrust have


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Turbine Research . . .

been developed, largely by increasing the temperature of operation. Studies of thermodynamics indicated that in this way progress lies. Each step has been dependent on the availability of better alloys, and it appears that the maximum properties of the best nickel alloys are now being reached. Useful properties are claimed for Nimonic 100 at 1740° F. but even higher temperatures are required. Metals of higher melting point are the next logical source.

The melting point of chromium is 570° F. higher than nickel and the density 12% less, but all known forms of the metal and its alloys were hard and brittle. Since 1954 research has been carried out in Australia to develop alloys of chromium for turbine blades to work at temperatures of 1650 to 1830° F. The conditions which control the ductility of chromium were first investigated. A ductile metal (20% elongation) was obtained by electrolysis which contained 0.002% nitrogen and virtually no metallic impurities. Heating in nitrogen to a content of 0.02% raised the ductile-brittle transition from –68° to 480° F. and confirmed that relatively nitrogen-free metal is ductile above room temperature. With this new metal, alloys with such solute metals as beryllium, titanium, zirconium and tungsten, all having very high melting points, were explored. Alloys prepared by electrolytic methods were tested for compression creep, hot hardness, scaling and forming at temperatures in the range of 1650 to 1830° F. It is concluded that these alloys operating at high temperatures and much slower rates of creep have equivalent properties to alloys in use at the present time. There is every indication that more highly alloyed metals will provide continued success.

Thermal shock, tensile creep and hot fatigue properties have yet to be explored. Hot working, machining, and grinding by the usual methods do not present any difficulty.

This discovery in the field of high-temperature materials adds that little important extra to existing knowledge which will produce important practical developments in power and efficiency.

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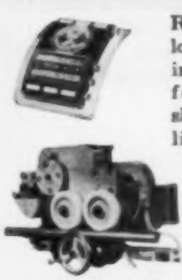

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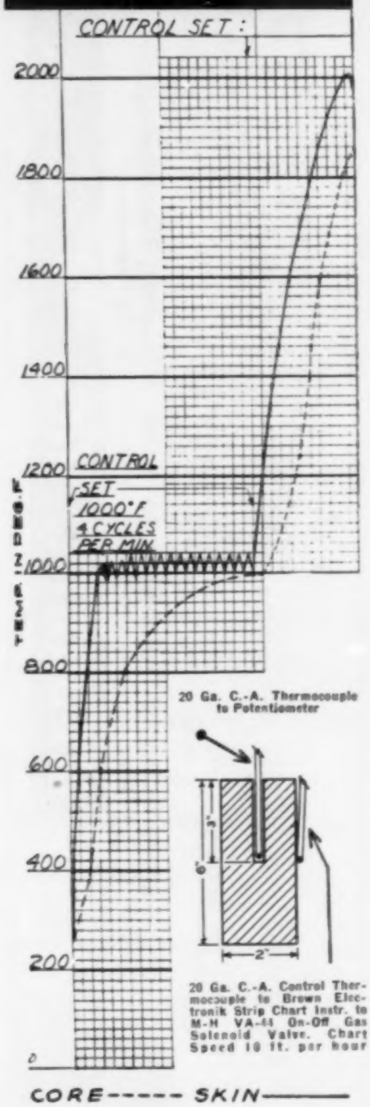

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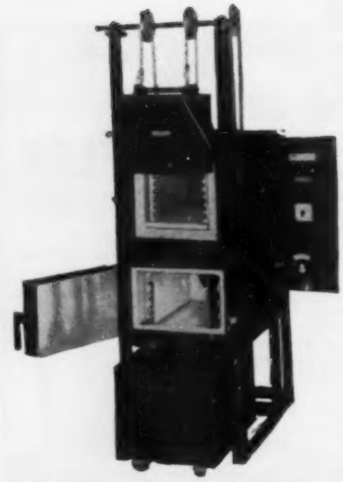

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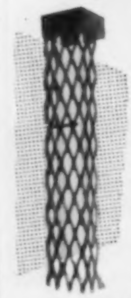

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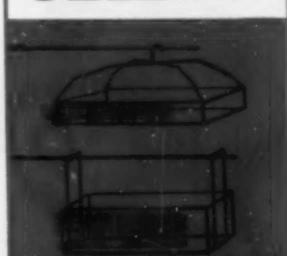

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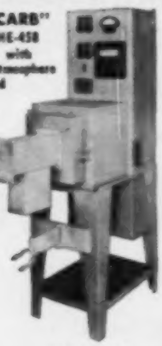

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Oxidation of 18-8 Steel at Forging Temperature

Digest of "Scaling of 18-8 Stainless Steel in Reheating Furnace Atmospheres", by J. O. Edstrom, *Journal*, Iron and Steel Institute, Vol. 185, April 1957, p. 450-466.

THIS LENGTHY paper describes the oxidation of the standard 18-8 Cr-Ni alloy in various synthetic gas mixtures at temperature of 1050° C. (1920° F.), the usual forging temperature for this alloy.

Experimental work consisted of exposing ground and washed samples of strip in a sealed glass tube and passing different gas mixtures, whose composition approximated that encountered in heating furnaces with respect to CO, CO_2, O_2, N_2, H_2, H_2O, and SO_2, at a rate of 5 cm. per sec. Specimens were exposed for periods of 5 to 120 min. and then examined for increase in weight (oxidation); scale was analyzed by chemical methods and X-ray diffraction, and microscopic methods were used for determining thickness of scale and intergranular chemical attack in the base metal beneath the scale.

Twenty different gas mixtures were used which would approximate the many different gas mixtures that are possible in furnaces heated by combustion of fuel oils. These mixtures fall into six different situations:

1. Highly oxidizing with excess air (17% CO_2, 1 to 2% O_2, 86% N_2).
2. Highly oxidizing with excess air and 0.1% SO_2.
3. Reducing conditions with gases containing 15 to 16% CO_2, 0.7 to 1.4% CO, 80 to 83% N_2.
4. Reducing conditions with gas similar to material in (3) with 0.10% SO_2.
5. Oxidizing conditions with 2 to 3% oxygen plus 8% H_2O, and 0.10 to 0.5% SO_2.
6. Reducing conditions with 5.1% CO, 5.4% H_2O, 0.3% SO_2.

Complete details of the results are given in tables, charts and 20 photomicrographs. The author gives a good review of previous papers on scaling of metals and a useful chart showing the free energies of the different oxide compounds involved in this research.

A chart showing oxidation attack for exposures up to 30 min. indicated least amount in the reducing gas, free of SO_2 (15% CO_2, 1% CO, 84% N_2). The same gas mixture with 0.1% SO_2 added showed four times as much gain in weight; the combination of SO_2 and CO gave the most severe attack and this effect was found repeatedly. On the other hand, when SO_2 was added to highly oxidizing gases such as 1.5% O_2, 0% CO, 0.1% SO_2 the effect of the SO_2 was negligible. This would strongly indicate that when sulphur-bearing fuel oil is used the furnace gases should contain excess air and no CO.

At longer periods of exposure a rapid increase in the rate of scaling in oxidizing atmospheres was observed after 75 min.; at 120 min. the reducing atmosphere (1.5% CO and no SO_2) reduced the rate of scaling by 50%. The author states that a "break through" occurs under oxidizing conditions which greatly accelerates the rate of oxidation. This is caused by the

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change from a slowly growing dense adherent scale for short exposure times to a loose flaky scale at longer periods. The initial oxide film was found to be Cr_2O_3 and this green scale changes in about 30 min. to a loose gray scale which contains several phases. These were identified as solid solutions of Cr_2O_3 and Fe_2O_3, spinels $FeO \cdot Cr_2O_3$ and finally iron oxides, FeO, Fe_3O_4, Fe_2O_3 which continually fall off and give little protection.

The striking and very detrimental effect of SO_2 (0.10%), in reducing gas mixtures is attributed to the formation of sulphides and oxysulphides which do not form protective layers and also melt at low temperatures, thus increasing the rate of diffusion from the atmosphere to the base metal. Extensive discussion of this sulphur effect based on the partial pressures of the corroding gases is given with a chart showing equilibria conditions in the various gas mixtures.

Extensive intergranular penetration of the base metal was found when both CO and SO_2 were present in the furnace gases.

The structural patterns of oxide layers formed on 18-8 steel at 1050° C. and in different types of atmosphere were studied by microscopic and X-ray diffraction methods. Special attention was paid to the microstructure of flaking and adherent oxide layers and influence of sulphur on oxidation structure.

In a reducing atmosphere (CO excess), free of sulphur, a thin adherent oxide formed. There was also a tendency to carburization.

In an oxidizing atmosphere (O_2 excess), free of sulphur, a thin adherent oxide appeared after short oxidation, and a flaky, thick oxide film after long oxidation.

In a sulphur-containing, moderately reducing atmosphere sulphides and thick adherent oxide films formed. There was also a tendency to carburization. In a heavily reducing atmosphere (CO > 10%) there were traces of sulphides, carburization, and a thin adherent oxide coating. In an oxidizing atmosphere containing SO_2, the results were the same as the sulphur-free gas.

Flaky oxide films formed in different ways consisted principally of

Oxidation of 18-8 . . .

iron oxides. In an oxidizing atmosphere a transition takes place from adherent to flaky oxide, which is associated with a chemical breakdown of an early formed, slowly growing oxide film with high chromium content. The phase sequence differs in oxidizing and reducing atmospheres, that is in a reducing atmosphere a wüstite layer forms outside the spinel phase in the scale. In oxidizing atmospheres the presence of sulphur has no effect on the oxidation result, whereas in a reducing atmosphere the presence of sulphur causes sulphide formation and a substantial rise in the rate of scaling. In heavily reducing atmospheres, however, the oxidation-promoting effect of the sulphur disappears.

The differing influence of sulphur on the oxidation process in oxidizing and reducing atmospheres has been explained by calculations of the sulphur vapor pressure in different gaseous mixtures. In a mixture produced by combustion of an oil under conditions of air deficiency, the sulphur pressures are high enough to permit the formation of low melting-point sulphides of Ni, Fe, etc. Under conditions of about stoichiometric combustion of the oil, or combustion in excess of air, on the other hand, the sulphur vapor pressures are too low for sulphides to form.

A hypothesis for the mechanism of oxide formation on 18-8 steel has been proposed, which provides an explanation of structural differences in scales formed under dissimilar conditions of oxidation.

E. C. Wright

Effect of Surface Roughness on Fatigue Strength

Digest of "The Influence of Surface Roughness on the Fatigue Strength of Steels and Nonferrous Alloys", by E. Siebel and M. Gaier, *V. D. I. Zeitschrift*, Vol. 98, Oct. 21, 1956, p. 1715-1723; translated and digested in *Engineers' Digest*, Vol. 18, March 1957, p. 109-112.

This experimental study of the effect of surface roughness on the fatigue properties of nine materials, tested after various heat treatments, was supplemented by an extensive literature survey. Torsion, bending, tension and push-pull fatigue tests were used to determine the influence of surface finish on the properties of five steels and four nonferrous alloys. The fatigue limits were evaluated by S-N curves run to 10 and 80 million stress cycles for steel and nonferrous specimens respectively. The maximum depth of groove on the surface of the specimen was chosen as the criterion for classifying surface roughness. This attribute appears to provide a suitable basis for comparison although the root-mean-square deviation from the average surface level is ordinarily used in the United States.

The authors found that the fatigue limit drops linearly with the logarithm of the maximum roughness depth after a critical roughness value is exceeded. The critical roughness value is independent of the type of

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Quick and easy as that is, you don't have to do it often. In fact, plant production manager Paul Davis says Chambers hasn't had to replace a single tube yet! After more than a year, the original 64 Inconel alloy tubes are still in service. And, he adds, still in good condition, despite operating temperatures of 1400-1520°F. (Tube temperature approximately: 1800°F.)

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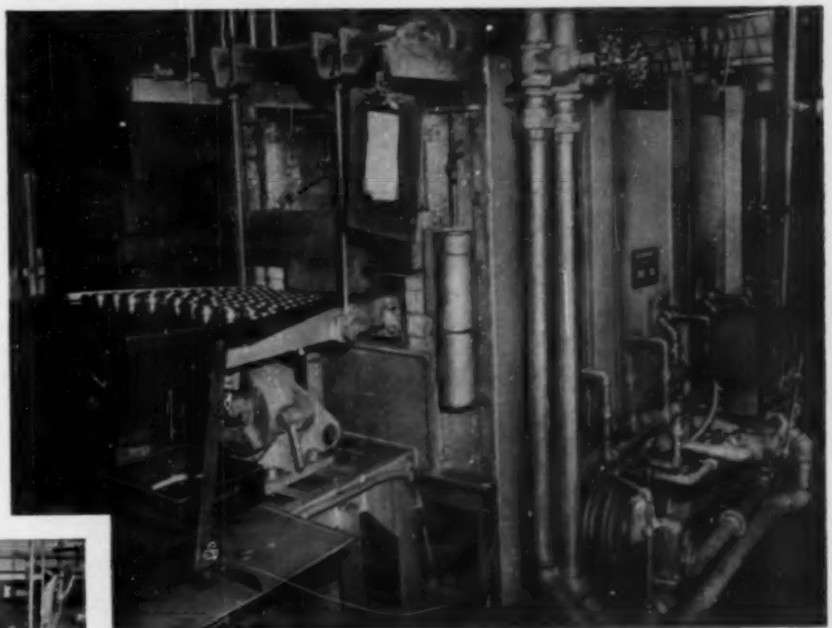
Fatigue Strength . . .

fatigue stress but varies with materials and with metallurgical structure. For steels tempered to relatively high strengths the critical roughness is about 1 to 2 microns, a smoothness which can be produced by honing or polishing. For annealed steels the critical roughness value is about 4 to 6μ, a finish attainable by fine grinding. Rough finishes are more harmful for harder steels. Increasing the maximum roughness depth to about 100μ lowers the bending fatigue strength about 25% for tempered steels and about 15% for annealed steels. Wrought nonferrous materials behaved in like manner. The critical roughness values were about 5μ for Al-Mg and Al-Cu alloys and 22μ for the magnesium alloys investigated.

The amount by which the fatigue strength decreases with increases in surface roughness depends upon the type of stress applied. Equivalent results were obtained in push-pull and fully reversed bending tests when the limiting stresses were comparable. Superimposing a higher static tensile stress in push-pull tests increased the deleterious effects of deep scratches. The reduction in fatigue strength under alternating tensile stresses is about 1.5 times that produced by the same surface roughness in fully reversed bending tests. Conversely it appears that the higher the imposed compressive stress the less important is surface roughness. Torsional fatigue properties are less sensitive to surface finish than are bending fatigue properties. For a particular roughness level, the reduction in torsional fatigue strength is about half that detected in bending tests because the major torsional stress is ordinarily aligned about 45° from the grooves on the part. The evidence is quite convincing that the influence of surface roughness on fatigue strength is independent of stress gradients within the specimen. If so, the effects should not vary with size but this point was not investigated.

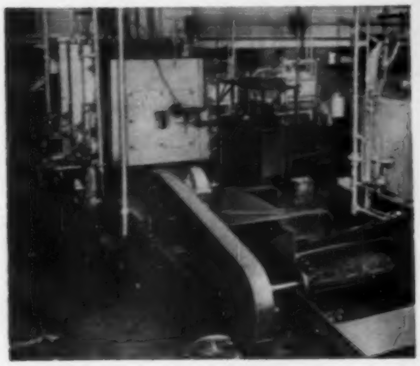
The findings can be summarized for use in deciding on surface finishes suitable for specific steel parts. For this purpose, surface roughnesses can be classified as classes 1, 2, 3 and 4, for ranges in maximum roughness of 0 to 2μ, 2 to 4μ, 5 to 25μ and

Lesson in low heat-hour cost at NORMA-HOFFMANN



(1) Charge end of Stewart Reciprocating Hearth Furnace showing bearing races entering. Average output is 125 pounds per hour. S.A.E. 52100 steel is hardened to 65-66 Rockwell C. Nichrome hearth casting has been operating over 9 years.

(2) At discharge end, ball races are dropped into conveyer tank and quenched from 1540–1550 degrees.



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Fatigue Strength . . .

25 to 160μ respectively. Increasing the maximum roughness depth above the critical value by one class lowers the bending or push-pull fatigue strength by about 10%. Smoothing the surface below the critical values of 2μ for tempered steels and 5μ for annealed steels confers no benefits. The fatigue strength of a part with a particular finish will also depend on the nature of the service stresses. This can be taken into account by using strength reduction factors of 0.5 for torsion, 1.0 for bending or push-pull, and 1.5 for tensile-tensile stresses.

Nitriding was shown to raise the fatigue strengths of steel and to minimize its dependence on surface roughness. Other investigations on notched specimens show that other kinds of surface hardening treatments such as carburizing and flame hardening have similar effects. Cold working by rolling or shot peening also raises fatigue strength and reduces the deleterious influence of surface roughness. These effects would be expected because the fracture of a surface hardened specimen ordinarily starts below the surface. Nevertheless the authors seem to attribute the benefits partially to the presence of compressive stresses in the surface layers of surface-hardened components. This uncertainty is typical of most articles on this subject but the reader is apt to conclude that the strengthening effect is more important. This view is supported by the data showing that stress-relieving steel specimens by heating them at 930° F. in a vacuum furnace did not change the fatigue strength of annealed or quenched and tempered medium-carbon steel.

F. W. Boulger

Forming and Joining Columbium

Digest of "Niobium", by F. G. Cox, *Welding and Metal Fabrication*, Vol. 24, October 1956, p. 352-358.

Despite its unusual mechanical and physical properties, columbium was of little industrial importance until designers of atomic reactors realized its potential utility. Until then its only important application was as a gettering material for removing reactive gases from electronic tubes. Now columbium is used as a protective coating for fuel elements in fast reactors cooled with liquid sodium-potassium alloy. Resistance to creep at elevated temperatures, compatibility with uranium, sodium, and potassium, good fabricating properties and a low neutron cross section are important properties for this application.

Pure columbium is a soft, ductile metal with a specific gravity of 8.6, somewhat heavier than iron. Typical properties of annealed specimens of commercially pure columbium are:

Young's modulus, 12.4×10^6 psi. at 70° F.; 4.7×10^6 psi. at 1020° F.

Ultimate tensile strength, 39,400 psi. at 70° F.; 32,200 psi. at 1020° F.

Elongation, 49% at 70° F.; 24% at 1020° F.

As might be inferred from these tensile properties, columbium has

Columbium . . .

reasonably good creep strength at elevated temperatures. Cox reports a creep rate of 2.3×10^{-6} in. per in. per hr. under a stress of 5000 psi. at 1110° F. in a 1359-hr. test on an annealed sample.

At elevated temperatures columbium reacts rapidly with oxygen, nitrogen, hydrogen, carbon monoxide and carbon dioxide. Contamination with these constituent elements produces hardening and embrittlement. The effects are pronounced; increasing the oxygen content from 0.03 to 0.56% raises the hardness of columbium from about 90 to 390 on the Vickers hardness scale.

Because columbium work hardens slowly, cold reductions up to 90% in area can usually be taken before annealing is necessary. This is especially desirable because cold working avoids the contamination caused by hot working in air. After heavy cold reductions, columbium should be annealed in a good vacuum for an hour at around 2450° F. Because of the high-purity atmospheres required, it is more expensive and less practical to employ inert-gas-atmosphere furnaces for annealing. It is comparatively easy to forge, roll or swage billets of columbium at room temperature.

Sheets can be rolled by normal procedures if appropriate lubricants are used to insure a good surface finish. Suitable lubrication is also important in wiredrawing and in deep drawing because the metal tends to seize or gall on dies and tools. Because of their slow rates of work hardening, columbium parts are characterized by less "spring-back" in forming processes and greater thinning in spinning operations.

High speed tools are recommended for machining columbium. The use of large relief and top rake angles on the tools and of proper cutting fluids minimizes the tendency for the metal to weld on the tools.

Columbium is neither corroded nor embrittled by molten sodium or sodium-potassium alloy – provided that liquid metals contain less than 40 ppm. of oxygen. Although resistant to corrosion by many chemicals, columbium is ordinarily less suitable for chemical plant applications then tantalum. *(Continued on p. 182)*

Columbium . . .

Special procedures are used in welding to avoid reactions with common gases or with constituents of welding fluxes. The inert-arc method is commonly used. In addition to covering the molten pool of weld metal, the argon blanket should protect the hot metal on both the face and back of the weldment from atmospheric contamination. It it comparatively easy to do this by directing streams of argon at proper locations when welding thin sheets without a filler rod. The problem is more difficult when the sections to be welded are thicker than 0.05 in. or require the use of welding rod. Both factors increase the size of the weld pool and the area that must be protected from air. The usual solution is to weld in a previously evacuated, argon-filled box. Machine welding is desirable because fast speeds reduce contamination of the weld and heat affected zones.

Resistance welding is recommended for columbium sheets thinner than about 0.020 in. Because of the shorter welding time involved, there is less likelihood of contamination than in fusion welding. Spot welding is often carried out in air; seam welding is preferably done under water in order to keep the metal cool. In either method the surfaces to be joined must be carefully cleaned and degreased. To avoid corrosion, any metal deposited on the columbium by the welding electrodes should be removed.

F. W. BOULGER

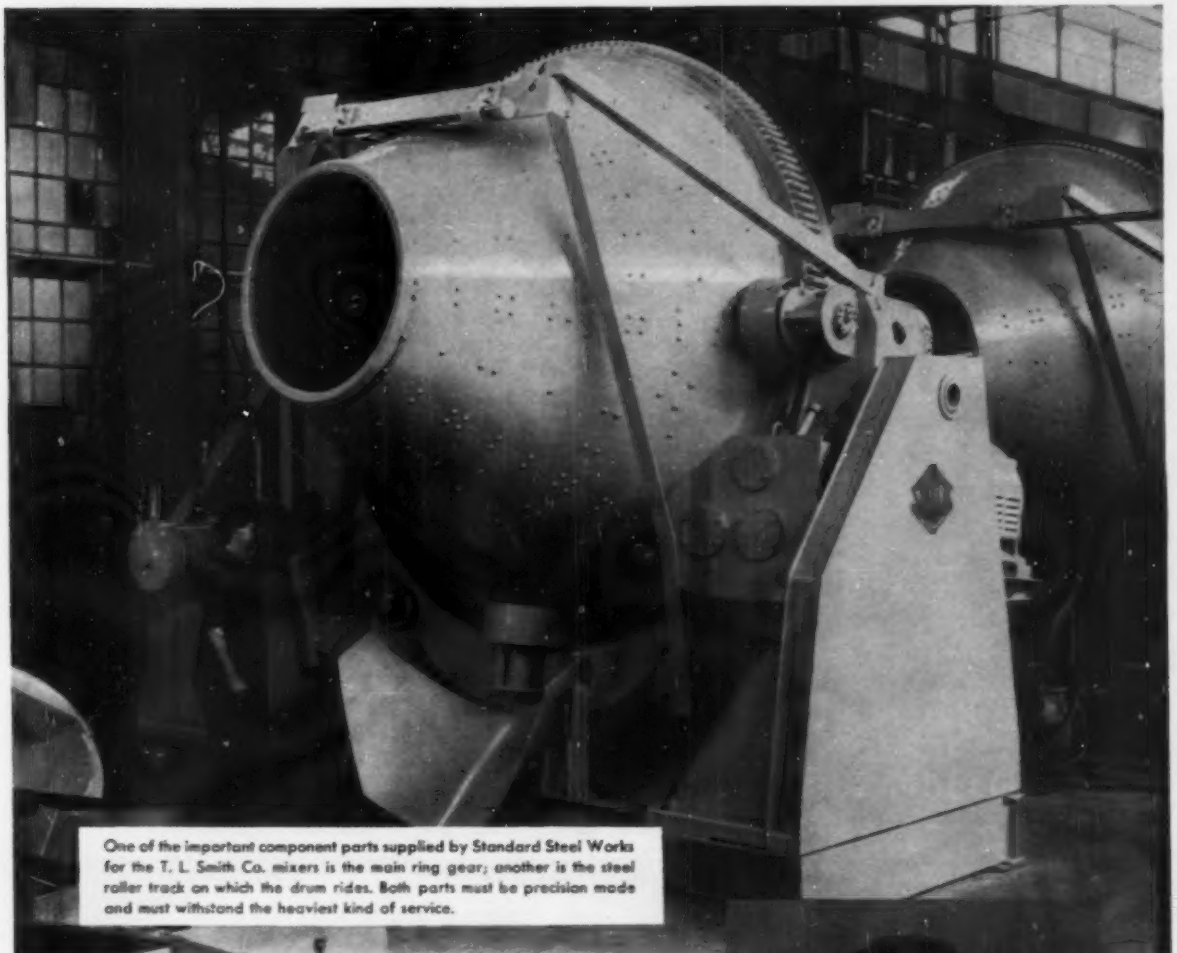
Nickel Plating of Jet Engine Parts

Digest of "Limitations of Plated Nickel in Jet Engine Design", by R. W. Moeller and W. A. Snell, *Annual Technical Proceedings*, American Electroplaters' Society, 1956; reprinted in *Electroplating and Metal Finishing*, Vol. 10, March 1957, p. 74-77.

WHERE operating temperatures are above the melting point of cadmium, nickel plating can be substituted to prevent corrosion in jet engines. However, the required high dimensional tolerances dictate a rather thin plating, 0.3 to 0.5 mil thick. Furthermore, the prevalence of high operating stresses makes residual stress due to nickel plating assume added importance.

Five different plating baths were used in preparation of test specimens. The residual stresses, the fatigue endurance and the corrosion resistance were determined. The residual stresses were measured in optical interferometer test pieces which were plated in Watts' type nickel sulphate solutions. Tests were made first at room temperature, then again at room temperature after heating 3 hr. at temperatures up to 1000° F. The endurance limit was determined by R. R. Moore rotating beam tests of 0.3-mil thick nickel-plated specimens prepared by plating from the same solutions and heating for 3 hr. at temperatures up to 1000° F.

Graphs show that for the specimen plated in a high-chloride Watts' type



One of the important component parts supplied by Standard Steel Works for the T. L. Smith Co. mixers is the main ring gear; another is the steel roller track on which the drum rides. Both parts must be precision made and must withstand the heaviest kind of service.

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Nickel Plating . . .

bath the residual stress plus applied stress equal the "par" value of an unplated specimen. However, the same bath purposely contaminated by intentional addition of iron (duplicating conditions existing in production plating operations) renders a loss in fatigue strength from the "par" value.

Another graph shows the residual stress in A.M.S. 2416 nickel-cadmium plated specimens after heating at the various temperatures for 3 hr. and their correlation with the endurance limit. There is an arch in the curve at 500° F. which may be related to the start of diffusion of the two separate plates which, prior to this point, are acting as a stressed nickel and a neutral cadmium plating. The fatigue strength of unplated specimens shows an average loss of 30,100 psi. due to the nickel-cadmium plating.

The sulphamate bath with a compressive stress additive produces nickel plates which show a constant but moderate increase in tensile stress from 350 to 1000° F. The chemical nickel plating bath produces brittle plates at age hardening temperatures.

Brittleness at age hardening temperatures, however, does not prevent the use of electroless nickel on low-stressed, low-alloy materials operating at low temperatures, particularly where the advantages of electroless application afford greatly improved corrosion resistance in recessed areas.

A. F. Mohrnheim

Coatings for Welding Electrodes

Digest of "Raw Materials for Welding Electrodes", by A. C. Demos, *Foote Prints*, Vol. 28, No. 2, 1956, p. 16-18.

The welding electrode is, in a sense, a miniscule electric steelmaking furnace, producing a highly refined metal from basic or crude raw materials. "Charge" in the electrode is the core wire plus surrounding flux and alloys in the coating. The furnace requires hours for refining the melt; the welding electrode has only seconds to do the same job.

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Welding Electrodes . . .

So, just as in steelmaking, deoxidation is a primary consideration in the formulation of welding electrodes and fluxes. Manganese and silicon, both pure and alloyed, are generally the favored deoxidizers, the former also contributing to strength and hardness of the carbon steels. Manganese may be obtained either as electrolytic metal powder or as low, medium or high-carbon ferromanganese. Similarly, silicon metal is produced in both the pure and ferro-alloy form. Ferrosilicon is most generally used. Careful control of particle size distribution of these additives is essential.

Particle size of alloy powders also has a major effect upon alloying efficiency. Coarser granulations result in greater alloy recovery. For example, in a mild steel E-6020 electrode, manganese recovery from coarse-mesh ferromanganese powder is much greater than it is from fine-mesh powder.

It is virtually impossible to produce metal powders free from −325 mesh particles. Furthermore, it is not always desirable to do so since factors such as deoxidation and electrode extrusion must be taken into account. Hence, alloy powders are produced with controlled particle size distribution to obtain optimum values for alloying efficiency, deoxidation and high extrusion rates.

Frequently, undesirable reactions occur in coating mixtures prior to and during electrode extrusion. One of the most troublesome is the disturbance generated when the sodium silicate binder comes in contact with the alloying constituents of the mixture. If the reaction becomes violent, it is referred to as "gassing". To eliminate the difficulty, "stabilized" metal powders have been developed by chemical surface treatment to render them inert to the action of sodium silicate solutions.

Many ferro-alloy and other metal powders are sufficiently unreactive to permit satisfactory use unstabilized under normal manufacturing conditions, but with the trend to more complex types of electrodes and coatings, the need for careful control of raw materials has become more imperative. The list of stabilized powders has grown to include

(*Continued on page* 188)

Welding Electrodes . . .

alloys of manganese, silicon and titanium.

Stability of alloy ingredients may be questioned if any of the following difficulties are encountered in electrode manufacture: (*a*) premature curing or hardening of the coating mixture, (*b*) bloating of the coating or cracking away from the core wire, and (*c*) excessive fuming and release of obnoxious odors during production. Arthur H. Allen

Movies Record Metal Fatigue

Digest of "Motion Pictures of Metal Fatigue Automatically Record Details", National Bureau of Standards, *Technical News Bulletin*, November 1956, Vol. 40, p. 153-154.

The National Bureau of Standards has constructed a small fatigue testing machine equipped with a motion picture camera for filming microscopic features of metal surfaces during fatigue. The apparatus uses a clock-controlled, 16-mm. camera to take time-lapse pictures of specimens under torsional stress. The work is sponsored by the N.A.C.A. as a study of the basic factors in fatigue crack initiation with the use of films simplifying tedious laboratory determinations by providing automatically recorded, detailed pictures of what happens during the fatigue process.

The fatigue testing machine is made to fit the stage of a metallurgical microscope with a horizontal collet holding the specimen. Two eccentric cams are mounted at the ends of a motor-driven shaft, parallel to but below the collet, with cam followers transmitting the loading to the ends of the collet. The specimen is placed in the collet and loaded in alternating torsion. A 0.01-in. hole drilled in the top surface of the specimen provides a focusing target for the microscope and also provides a stress concentration to increase the possibility of fatigue failure developing in the field of the microscope.

The camera is attached to the principal eyepiece; a second eyepiece permits simultaneous visual observation. Timing is synchronized with shaft rotation so that successive exposures always occur at the same point of the stress cycle. Each frame may be exposed a number of times; the number of stress cycles per frame can be varied depending on the rapidity of changes in appearance of the specimen.

Tests have been made with this machine using aluminum specimens. During the early stages, slip bands developed in the highly stressed regions around the hole, gradually becoming more numerous and heavier until some developed into cracks. During the later stages a crack developed in an area which had contained no slip bands in the early stages of the test. Material was extruded from this crack at irregular intervals. The phenomenon occurred suddenly and was not observed until the film was developed and viewed. Although no attempt could be made to analyze the extruded material, it has been postulated that, if not an oxide, it was so finely divided that it immediately reacted with the atmosphere to form one.

C. O. Smith

Columbia Tool Steels for 1957-58
with A.I.S.I. Identification and Type Classification of Tool Steels

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GRADE	Type	C	Mn	Si	Cr	Ni	V	W	Mo	Co	Cb
		Identifying Elements, in Per Cent									
HOT WORK TOOL STEELS — TYPE SYMBOL H											
H1-H19, INCL., CHROMIUM BASE TYPES (H1-H10 AND H17-H19 UNASSIGNED)											
FIREDIE-CASTDIE	H11	.35	—	—	5.00	—	.40	—	1.50	—	—
ALCODIE	H12	.35	—	—	5.00	—	.40	1.50	1.50	—	—
VANADIUM CASTDIE	H13	.35	—	—	5.00	—	1.00	—	1.50	—	—
	H14	.40	—	—	5.00	—	—	5.00	—	—	—
	H15	.40	—	—	5.00	—	—	—	5.00	—	—
	H16	.55	—	—	7.00	—	—	7.00	—	—	—
H20-H39, INCL., TUNGSTEN BASE TYPES (H27-H39 UNASSIGNED)											
	H20	.35	—	—	2.00	—	—	9.00	—	—	—
FORMITE 2	H21	.35	—	—	3.50	—	—	9.00	—	—	—
	H22	.35	—	—	2.00	—	—	11.00	—	—	—
	H23	.30	—	—	12.00	—	—	12.00	—	—	—
FORMITE 3	H24	.45	—	—	3.00	—	—	15.00	—	—	—
	H25	.25	—	—	4.00	—	—	15.00	—	—	—
CLARITE J	H26	.50	—	—	4.00	—	1.00	18.00	—	—	—
CLARITE HW	H26	.50	—	—	4.00	—	1.00	18.00	—	—	—
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Notes About Authors

Andrew W. Kramer

Andrew W. Kramer has been on the editorial staff of *Power Engineering* for nearly 35 years, as electrical editor, managing editor, and since 1948 as editor. As evidence of his active interest in nuclear power, he has been editor of *Atomics*, a periodic report on atomic energy developments throughout the world since 1946, and is a member of the U.S. Atomic Energy Commission Advisory Committee on Industrial Information. In addition, he participated in the first atomic bomb test expedition to Bikini in 1946.

Hubert Sutton

Hubert Sutton, author of "Progress of Metallurgy in Europe", completed his technical studies at Manchester University in England, receiving his bachelor's, master's and, in 1935 his doctor's degrees from that institution. The greater part of his career has been spent in the field of aeronautics, first with the Royal Aircraft Establishment at Farnborough, and now at the Ministry of Supply. Joining the Royal Aircraft Establishment in 1918, he served as head of the metallurgy department until 1943, when he joined the Ministry of Supply. His official title is director of materials research and development (air). His awards include the Simms Gold Medal of the Royal Aeronautical Society (1929), the same society's Silver Medal (1952) and Commander of the British Empire (1952).

Adalbert Wittmoser

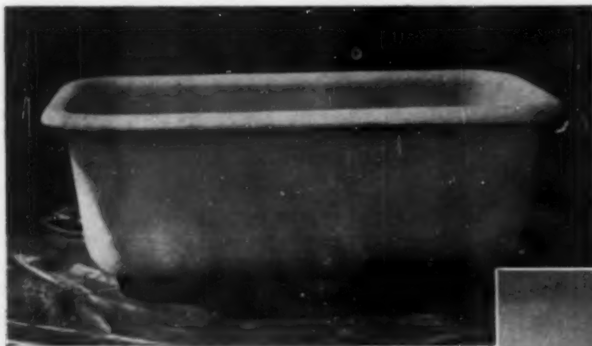
A native of Lithuania, Adalbert Wittmoser was active in his family iron foundry business in Mariampole until 1938 when he went to Germany to study at the Technical University in Aachen. He received his master's degree there in 1942 and, while working as an assistant in the University's Institute of Technology, completed his studies toward a doctorate. In 1949 he became manager of the research department of the Eisenwerke Gelsenkirchen A. G. in Gelsenkirchen, Germany, and for the past two years has been director of research for the company. He is also an assistant professor of foundry technology at the Technical University of Aachen.

W. E. Hoare

An authority on the tinplate industry throughout the world, W. E. Hoare is assistant director of the Tin Research Institute in London. Graduating from London University, he worked for the Talbot Motor Co. and the Building Research Station until 1932 when he undertook postgraduate research at Sir John Cass College under a fellowship sponsored by the International Tin Research and Development Council. He has been on the staff of the Tin Research Institute for nearly 25 years, first as development officer and later as head of the tinplate section, becoming assistant director in 1955. He was awarded a D.Sc. degree in 1954, and is a co-author of the standard textbook on the subject of tinplate.

B. R. Nijhawan

B. R. Nijhawan, director of the National Metallurgical Laboratory, Jamshedpur, India, is familiar not only with metallurgical research and production in his own country but



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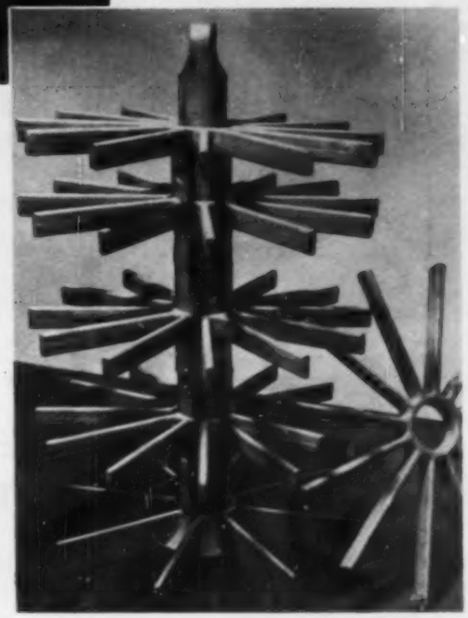

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Authors . . .

throughout the rest of the world as well. As a United Nations' Fellow and Indian government delegate, he has made extensive tours through installations in the United States, Australia and Europe. Soon after graduating from Banaras Hindu University, he was awarded a state scholarship for advanced metallurgical research and study in Great Britain. He received his doctorate in 1941 from Sheffield University, and returned to India to work as a research officer for the Government, joining the National Metallurgical Laboratory in 1948.

Donald L. Colwell

The die casting field has been the primary interest of Donald L. Colwell, author of "Review of Die Casting Practices Abroad", for more than 30 years. After graduation from the University of Chicago, he worked with the Stewart Die Casting Div., Stewart Warner Corp., Chicago, for 20 years, first as metallurgist and later sales manager. Following five years war service with the Government in the War Production Board and Navy Dept., he became a sales engineer and then director of laboratories for the Apex Smelting Co., Chicago, and in 1953 tranferred to the Cleveland branch of the company in the same position. Last fall he was promoted to vice-president in charge of laboratories and research for Apex. He is a past chairman of the Chicago chapter, the Chicago Section of A.I.M.E. and the Chicago District Council of A.S.T.M.

(*Continued on p.* 194)

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Juan B. De Nardo

Juan B. De Nardo, a metallurgist at the Villa Lugano Arsenal (Fabrica Militar de Aceros) in Argentina, received his technical education in Argentina and the United States, completing his studies for a doctorate in 1940. Since that time he has been a professor on the faculty of various schools in his country, including a tenure as professor of metallurgy at the Technical School No. 1 of Buenos Aires and as superintendent of the Technical Institute for 14 years. Currently he is a professor on the faculty of the University of La Plata. Dr. De Nardo has often served in a technical advisory capacity to the Argentine Government.

Georges A. Baudart

Born in Glasgow, Scotland, Mr. Baudart was educated in France and in 1939 joined the Aluminium Francais group. He now is information and marketing officer for the organization and, in addition, serves as economic editor of the French monthly, *Revue de l'Aluminium.*

Powder Metallurgy . . .

(*Starts on p.* 105)

comparable German types." This situation may well be on the mend. For example, we find in recent Russian literature some discussions of the effect of a titanium carbide addition to the conventional cobalt-cemented tungsten carbide mixture and the application of vacuum techniques. Professors Meerson and Samsanov have also studied tools made with unequal distribution of the carbide component, and find they give superior results when machining abrasive materials. They believe that the brittleness of the standard WK3 tool with 3% cobalt binder is due to segregation of the $WC\text{-}W_2C$ eutectic. They therefore make up a compact of alternate layers of WK3 powder mixtures of 0.5 to 3-mm. size, and of WC plus 15% cobalt. The tools were hot pressed at temperatures suitable for the high-cobalt layers, and time at temperature was limited to avoid much diffusion, layer to layer. Subsequent annealing was below the pressing temperature.

An important powder metallurgy meeting was recently held in Eastern Germany (Eisenach, June 1957). The presence of Professor Rakovski and other leading Russian powder metallurgists at this and similar meetings in countries behind the Iron Curtain* indicates that Russia not only emphasizes the importance of powder metallurgy, but acts strongly as a stimulator in other countries.

Hydrogen Embrittlement by Furnace Atmosphere

Digest of "Hydrogen Embrittlement of Gas Carburized Steel", by S. Gunnerson, *Härtereitechnik und Wärmebehandlung*, Vol. 2, January 1956, p 1-5.

IN GOTHENBURG, SWEDEN, SKF has experienced cracking in large roller bearings which is believed to be caused by hydrogen embrittlement of gas carburized steel. The material is a steel containing nominally 0.12% C, 4.2% Ni, and 1.1%

*At a Symposium on Powder Metallurgy held in Prague, Czechoslovakia, in 1953, 63 papers were presented.

Cr; A.S.T.M. grain size values vary between 0 and 5.

The rollers are carburized to a case depth of approximately 4.5 mm. (0.18 in.), necessitating about 85 hr. at 1700° F. The carburizing gas is generated in the furnace by thermal dissociation of organic liquids, consisting primarily of eth[illegible] Carburizing occupies [illegible] essing time and is d[illegible] phere of 4.0% CH_4, [illegible] % CO, and 57.3% H_2. Di[illegible] takes place during the rest of the heat treating cycle. The atmosphere at this time consists of 2.5% CH_4, 17.0 N_2, 39.5 CO, and 41.0 H_2.

Hydrogen Content of Carburized Cases

Extraction Temp.	Condition	H_2 Content Ppm.
1110° F.	As received	0.60
1110	Gas carburized 69 hr. at 1700° F.; quenched in water	3.23
1110	Gas carburized 69 hr. at 1700° F.; transformed [illegible]o bainite (16 hr. at 570° F.)	1.44
660	Gas carburized 71½ hr. at 1700° F.; quench[illegible] in water (extraction time 11 hr.)	2.40

The steel was thus exposed to an atmosphere containing 57% H_2 for 25 hr., and for an additional 60 hr. to an atmosphere containing 41% H_2. Conditions such as this favor hydrogen absorption in steel. Calculations indicate that the amount of active hydrogen liberated by the [illegible]thane reaction is of sufficient mag[illegible]tude to cause a marked hydrogen [illegible]bsorption in steel. This may lead to permanent damage during subsequent processing.

Gas carburizing results in surface carbon contents ranging between 0.9 and 1.0% C. To facilitate any further processing it is desirable to quench the material directly to prevent carbide formation in the grain boundaries and through the grain.

A certain number of gas carburized and salt bath quenched rolls cracked at the completion of the heat treatment. The fractures exhibited the typical appearance ot flakes (the central portion was silvery-white and flat). The majority of these flakes were transcrystalline. Generally, the fracture was fine-grained in appearance, and its path followed the outline of the case.

The hypothesis was advanced that the flakes, occurring after quenching, are the result of the combined effects of hydrogen embrittlement and transformation stresses. In the latter stages of the thermal cycles the larger flakes act as points of origin for transformation and stress cracks. The more drastic the quenching operation, the more pronounced was the formation of flakes.

To prevent cracking due to hydrogen embrittlement the author suggests fitting the temperature of the salt bath to the bainite nose of the TTT-curve, and extending the hold-

Embrittlement . . .

ing period to 16 hr. to obtain as complete a transformation of the microstructure as possible. This also results in a pronounced lessening of the hydrogen content.

According to Dana, Shortsleeve, and Troiano, the prevailing micostructure exerts a deciding influence on flake formation. A steel completely transformed to pearlite will not flake during a subsequent cooling or aging treatment even in the presence of relatively high hydrogen contents. To obtain a fine and uniform carbide distribution in the fully hardened condition the austenite should be transformed before hardening. Decarburization should be prevented at temperatures around 1110° F.

Several determinations of the hydrogen content were made by heating samples in vacuo. Results, as shown in the table, support the suggested mechanism for the formation of flakes.

Factors favoring the occurrence of flakes or cracks or both appear to be the following: (*a*) long carburizing periods in an atmosphere rich in hydrogen, (*b*) drastic quenching coupled with high residual stresses, and (*c*) a microstructure which is conducive to the formation of hydrogen flakes. HANS HEINE

Permanent Mold Castings

Digest of "Thin Permanent-Mold Castings", by A. M. Petrichenko, *Liteinoe Proizvodstvo*, No. 7, 1955, p. 4-8; translated and digested in *Iron & Steel;* Vol. 29, October 1956, p. 473-477.

IN THIS COUNTRY, permanent molds are not ordinarily used for castings made from gray iron. The Russians, however, use the process for producing thin-walled castings so as to lessen the tendency for cast iron to develop a chilled microstructure when cast in thin sections.

The composition of the iron has an important effect on the chill depth of castings poured under otherwise similar conditions. Increasing silicon contents up to 3.2%, manganese up to 1.0%, and phosphorus from 0.6 to 1.0%, helps to avoid a chilled structure in light sections. On the other hand, it is desirable to keep

chromium and sulphur contents below 0.1%.

Cooling rates are also important. Experience teaches that minimizing the drop in temperature of the iron before pouring helps to reduce the chill depth of thin sections cast in permanent molds. The use of insulating-type mold washes is also desirable. Pastes or paints containing about 30% graphite and 35% crushed ferrosilicon are used on molds preheated to about 500° F. These practices are suitable for castings with wall thicknesses ranging from 3/16 to ⅜ in. Permanent molds for thinner castings should be preheated to higher temperatures to prevent chilling and underfilling. The custom is to apply mold coatings, approximately 0.04 in. thick, containing crushed magnesite, clay and graphite to molds which are preheated above 550° F.

Contrary to the reports by some investigators, Petrichenko believes that the thickness of the molds used for casting light sections has little effect on chill depth. However, other features of mold design are important in production operations. Molds should be designed for rapid filling to secure sound castings and for quick removal of the castings in order to minimize chilling. Inserts are used in regions where mold wear is excessive. It is desirable to use the same design for gates and risers so they can be used alternately for pouring, thus avoiding severely localized heating. Most of the casting surface should be formed by the metal part of the mold because the use of sand cores causes complications. Permanent molds should be easy to assemble and the design should insure uniform cooling in order to minimize distortion encountered in service.

Vertical, book-type, split molds are recommended for shallow castings such as frying pans and lids. They offer advantages over horizontal molds from the standpoints of uniform heat flow, choice of feeding methods and maintenance costs. Vertical molds are also preferred for rangy castings with thicker sections such as parts for kitchen stoves. Molds for deep castings, such as pots, should be split along a vertical plane of symmetry and horizontally at the base of the casting; the casting system is attached to this plane.

F. W. Boulger

MOLY NEWS

CLIMAX MOLYBDENUM COMPANY, 500 FIFTH AVENUE, NEW YORK 36, N. Y.

Super-Strength Structural Steels Boost Minimum Yield Strengths to 150,000 psi.

Seven steel companies in the U. S. are now producing a group of "Super-Strength Structural Steels" with considerably higher yield strengths than the well-known "High-Strength Low-Alloy" steels.

These Super-Strength steels offer minimum yield strengths ranging from 55,000 to 150,000 psi. And they have other useful properties, depending on composition, including strength at moderate temperatures, toughness at low temperatures, and good wear resistance. Almost all of these steels contain molybdenum as an essential element.

The search for steels with greater yield strengths has gone on for many years. Before about 1930, carbon steels with a yield point of roughly 30,000 psi were standard for almost all structural purposes. Then came the development of "High-Strength Low-Alloy" steels. They boosted minimum yields into the 50,000 psi range.

Now, the newer Super-Strength Structural Steels are being welcomed by designers, who see in them a way to solve one of their major problems — to minimize weight and size while retaining quality and reliability.

. . . For more information on these steels, including their trade names and compositions, circle number 1 on the coupon.

Moly's High Hot Strength Shows Promise for Jets and Rockets

Molybdenum-base alloys were described at the 1955 American Rocket Society annual meeting as having the greatest promise for true high-temperature operation.

Missile and powerplant designers are interested in moly mainly for its high temperature strength. Molybdenum-base alloys have been developed with higher useful strength at temperatures over 1600 F than any other presently known metallic material.

The jet propulsion field — including guided missiles and aircraft powered by rocket, ramjet, and turbojet engines — covers a tremendous variety of requirements and service conditions in respect to temperature, atmosphere, amount and type of stress, vibration, thermal shock, and prospective life. Molybdenum's properties make it a logical choice in many cases because it has:

1. High creep and rupture strength.
2. High tensile strength at high temperatures.
3. High modulus of elasticity.
4. A combination of high thermal conductivity, low specific heat, and low expansivity, which minimizes non-uniform temperature distribution and makes molybdenum insensitive to thermal shock.
5. High resistance to erosion by hot gases.
6. High melting point.

It seems safe to conclude that molybdenum-base alloys will become important structural materials in the jet propulsion field. And they will become essential for many parts operating at temperatures in excess of 1600 F.

. . . from "Molybdenum for High strength at High Temperatures," by R. Freeman and J. Briggs, JET PROPULSION, *February, 1957.*

For a copy of the complete article, circle number 2 on the coupon.

Moly Adds Strength and Corrosion Resistance to Titanium

Commercially pure titanium is fairly strong and highly corrosion-resistant. Alloying it, however, substantially increases these useful properties.

Molybdenum may prove to be one of the most useful of the alloying elements for titanium. Studies at Armour Research Foundation, for example, show that when molybdenum is used instead of vanadium, creep properties are greatly improved. At 1020 F, a stress of approximately 20,000 psi produces a creep rate of 10^{-4} in. per in. per hr in Ti-6 Al and Ti-6 Al-4 V, whereas 40,000 psi is required to produce the same creep rate in a Ti-7 Al-3 Mo alloy.

In summary, new alloy development is opening the way for titanium's extensive use in jet engines and air frames. Ti-Al-Mo alloys, for example, give better elevated temperature properties than the Ti-6 Al-4 V alloy now most widely used. And the alloy containing 7% Al and 3% Mo appears particularly promising.

Another Ti-Mo alloy contains 30 to 40% Mo. This alloy is claimed to resist boiling 40% sulphuric acid and boiling 20% hydrochloric acid as well as platinum, tantalum or gold. Such a retained beta alloy is weldable and could be fabricated into sheet. These corrosion-resistant characteristics would add to the value of all-beta Ti-Mo alloys.

. . . from "Molybdenum as an Alloy Addition for Titanium," by Harold Margolin, METAL PROGRESS, *February, 1957.*

For a copy of the complete article, circle number 3 on the coupon.

Moly Goes to Sea In A Sewer

Cast iron joint ring in pipe, before lowering into position. Joint rings were made by Alhambra Foundry Co., Ltd. and the concrete pipes poured by American Pipe and Construction Co.

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Examination of pipe lengths after six years' service showed them in excellent condition. Equally good performance is expected from the most recent installations which extend some 8000 feet into the Pacific Ocean, and are believed to be among the largest in the country.

. . . For more information on the contribution of moly to toughness and shock resistance of cast iron, circle number 4 on the coupon.

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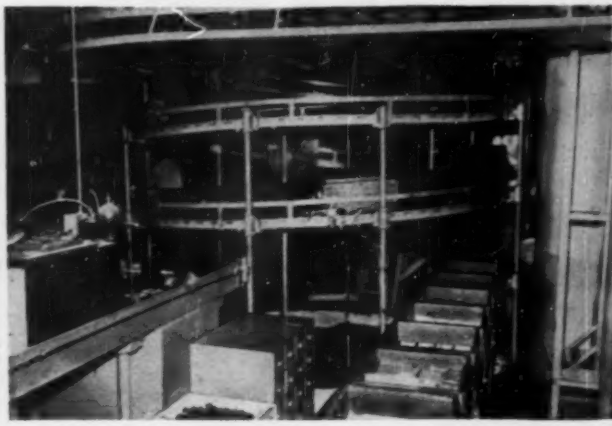

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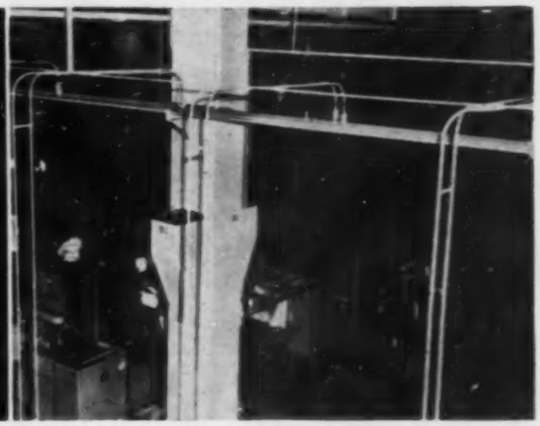

and schedule on record . . . and advises furnace man when heat treat is finished. Control room overlooks heat treat floor

nerve center of heat treat department

Heat treating operations include carburizing, hardening, tempering, annealing, sintering, brazing, etc. Furnaces are electric . . . both batch and continuous . . . and include gas carburizers, cyanide pots, salt pots, lead pots, bell annealers, draw furnaces, induction heaters, sintering furnaces, etc. Parts are made of various steels—from low carbon strip to various alloys—and in order to give the wear and service expected of a quality product, each part must—and does—meet *precise heat treating specifications.*

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. . . . opens with Fundamental Considerations of Residual Elements. A description of each type of imperfection is presented, followed by a discussion of the interaction between imperfections and trace elements. The first section concludes with a description of the effect of minor constituents on fracture, corrosion, nucleation and growth. This important and fundamental study is extremely well written by E. R. Parker, Professor of Metallurgy, University of California.

F. N. Rhines, Alcoa Professor of Light Metals, Carnegie Institute of Technology, follows with an absorbing presentation on the Impurities in the Common Nonferrous Metals. Aluminum, copper, nickel and magnesium are sampled for some of the better known effects of impurities. Many charts, tables and photographs aid in the effectiveness of this material.

James W. Halley, Assistant Superintendent, Research & Development Department, Indiana Harbor Works, writes of Residual Elements in Steel throughout section three. After explaining that the elements found in finished steel which have not been added intentionally are considered residual elements, he goes on to show how these "left over" impurities may be essential to the proper functioning of the steel. The source of these impurities is interestingly described, as is their individual importance and effects.

In Impurities in Semiconductors, composing section four, you find an entirely different situation. Whereas, in the prior sections, the effect of impurities has been largely of an adverse nature, here we find the more favorable and necessary aspects of residual elements. J. H. Scaff, Bell Telephone Laboratories, explains that the properties of semiconductors are basically dependent on the presence of trace elements or "impurities" in the substance.

Residual elements, in Newer Metals—Titanium, Zirconium, Molybdenum, and Chromium, are reviewed in the final section. D. J. McPherson, Metals Research Department, Armour Research Foundation of Illinois Institute of Technology, gives an interesting progress report of the excellent research currently being conducted on all four metals.

This is but a brief summary of the content of *Effect of Residual Elements on the Properties of Metals.* Here are 217 pages of authoritatively written, current metals information attractively bound in red cloth—6x9. Order your copy today for a better understanding of metals.

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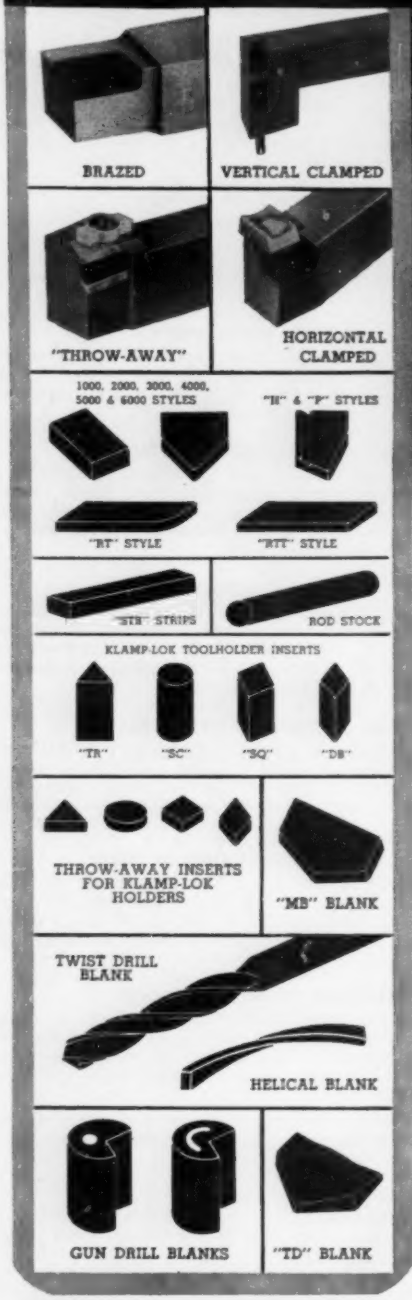

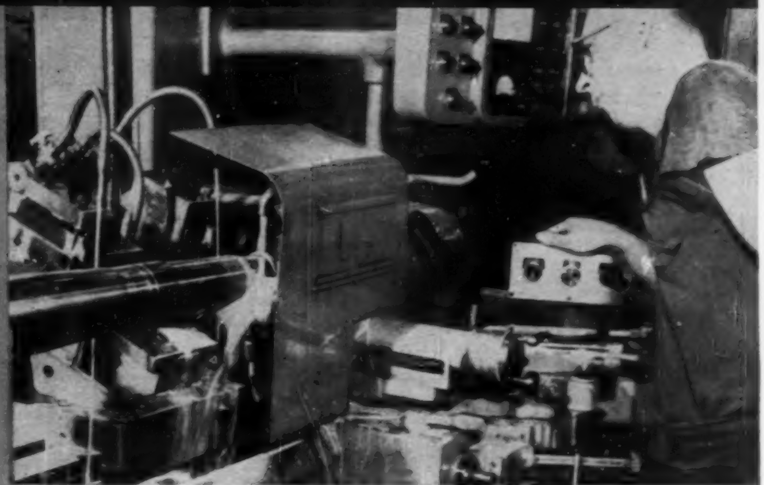

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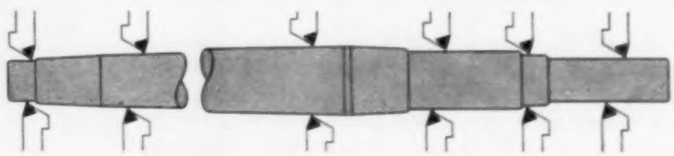

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Part	Crawler Tractor Axle Shaft
Material	SAE 8645 Steel Forging $3\frac{1}{4}$" dia. x $38\frac{1}{2}$" long, 3.6mm Brinell Hardness.
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Tools	12 Talide TB-164 $\frac{1}{2}$" I.C. Triangular TALIDE Throw-Away Inserts mounted in Klamp-Lok Toolholders, Grade S-92.
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Feed	6" per min.—.018 F.P.R.
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Coolant	Soluble Oil and Water
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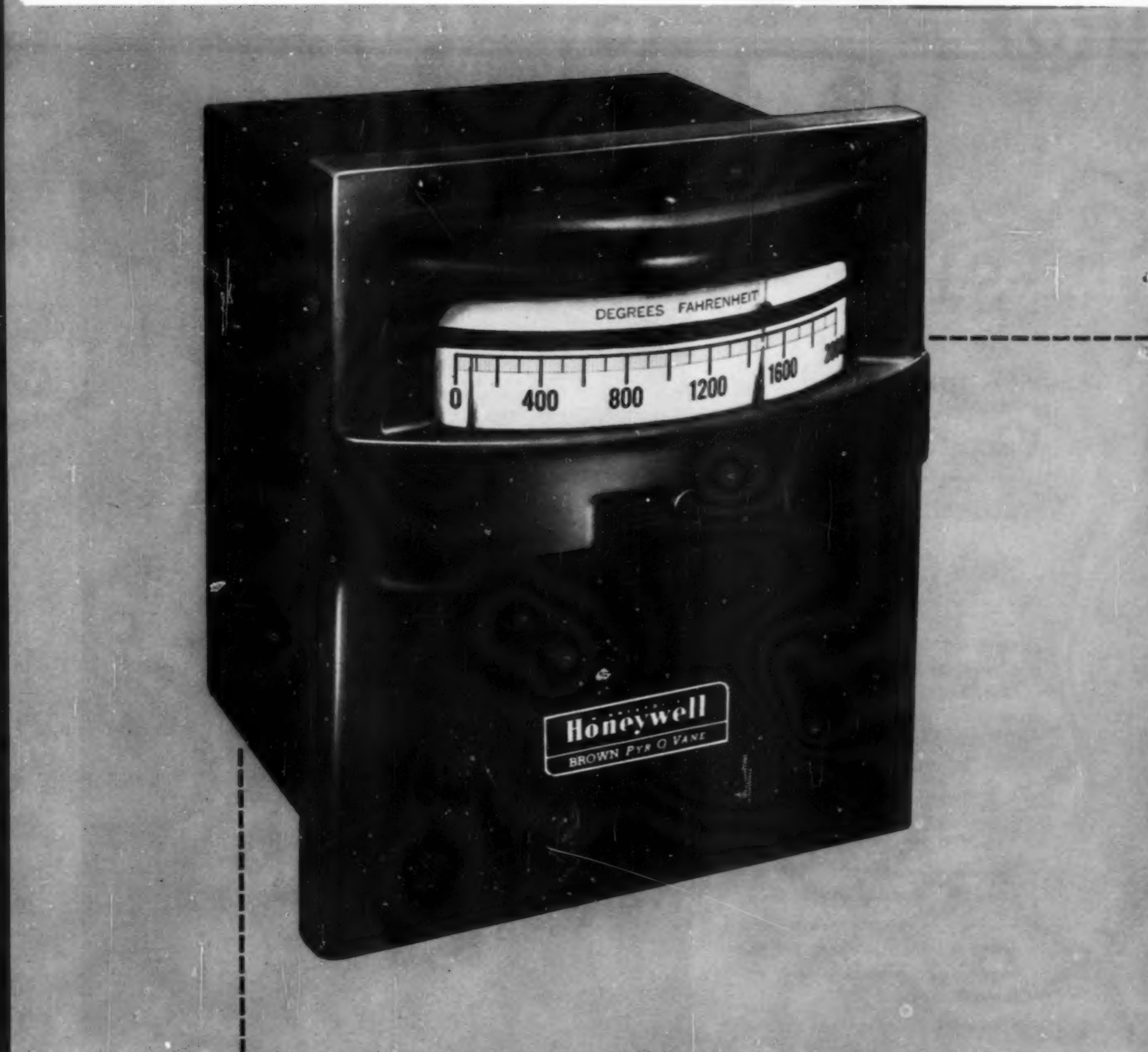

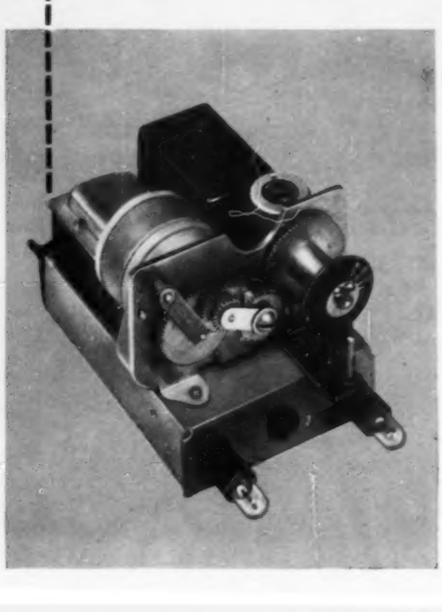

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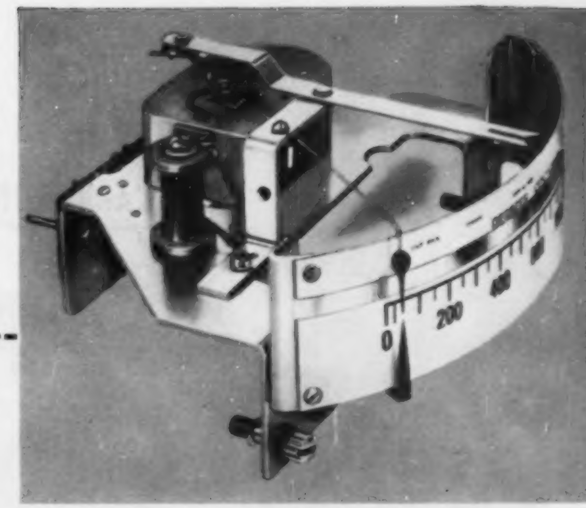

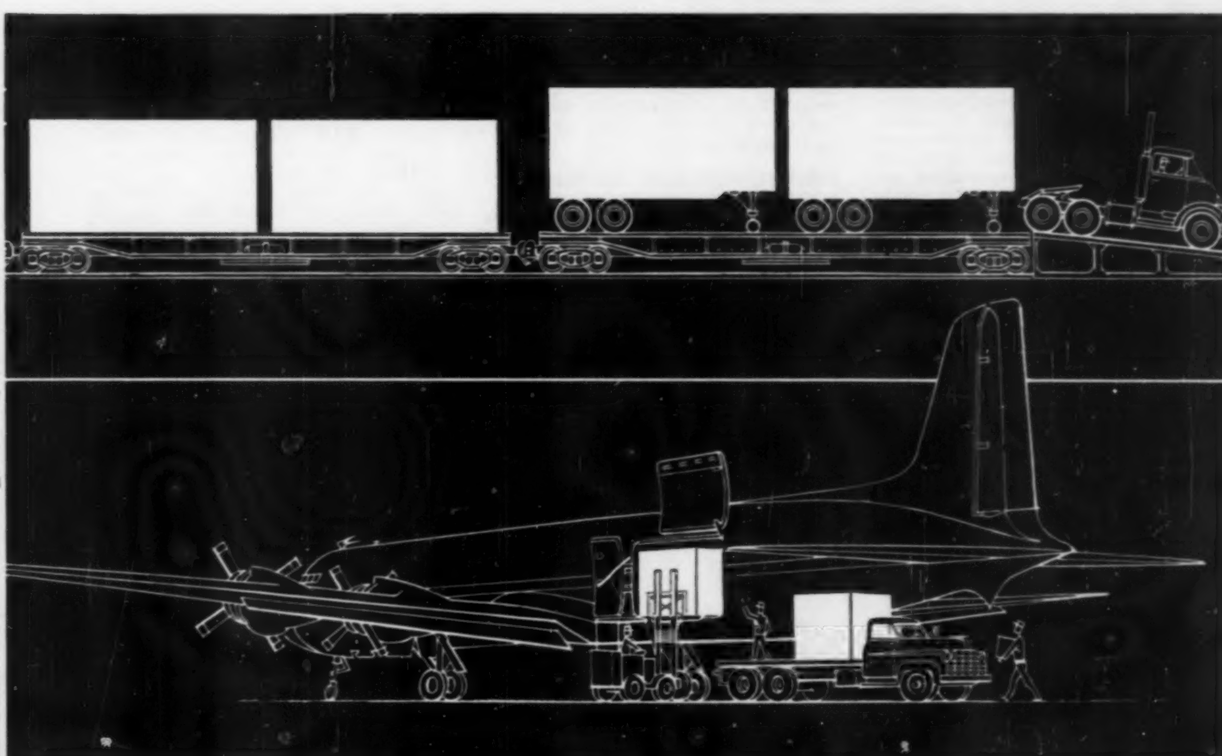

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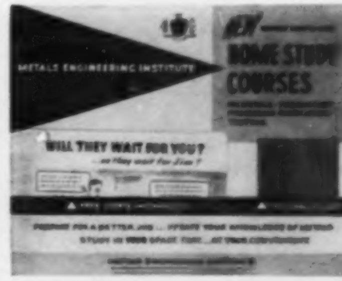
Anton deS. Brasunas

Anton deSales Brasunas, Director
METALS ENGINEERING INSTITUTE

Dr. Anton deSales Brasunas was appointed Director of the Metals Engineering Institute after a long search for just the right man who, by education and experience, would most ideally qualify for this important post. Dr. Brasunas came to MEI from the University of Tennessee where he was Associate Professor of Metallurgical Engineering. Prior to that time, he was associated with the Oak Ridge National Laboratory and with Battelle Memorial Institute. He is a graduate of Antioch College, received his MSc. degree from Ohio State University, his Sc.D degree from Massachusetts Institute of Technology.



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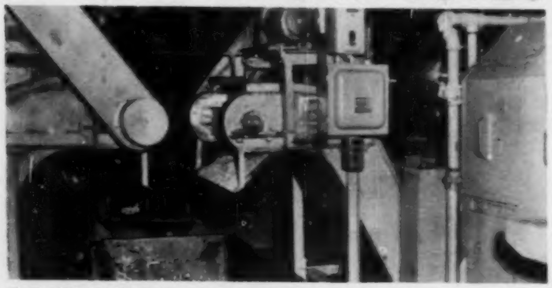

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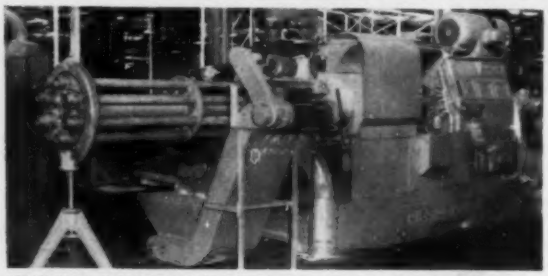

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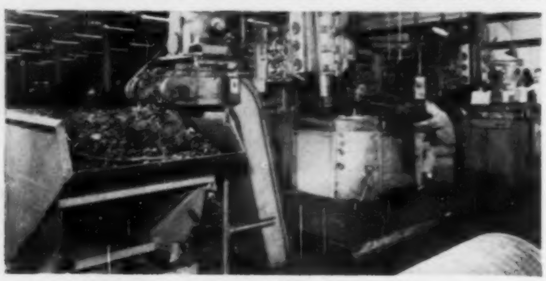

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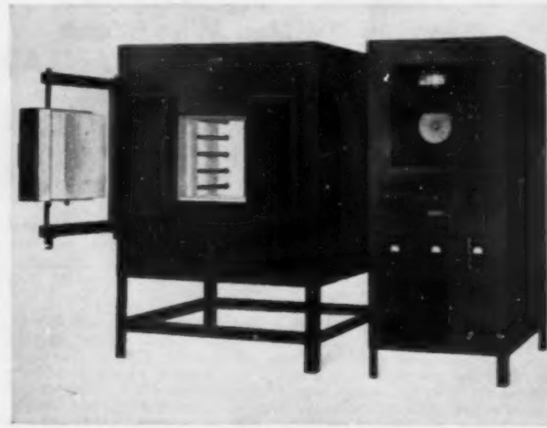

NMR-20 Standard Harrop Furnace with Instrumentation and Control Unit

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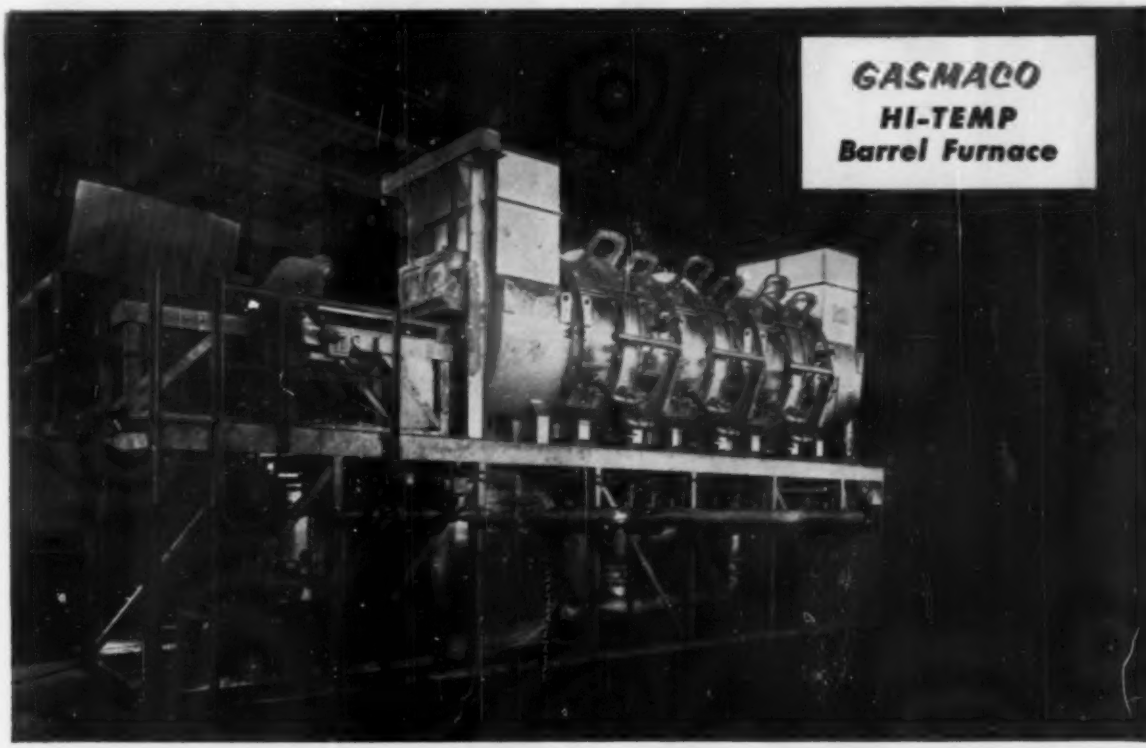

GASMACO Hi-Temp Barrel Furnace Gives Hi-Speed Heating

This forge shop turned up the heat and cut down scale on a slug heating operation by installation of the Pusher-Type Furnace pictured. The furnace not only produced — but its unique design overcame high maintenance related to furnaces of this type. This furnace is ideal for any operation where short billets or slugs can be pushed end to end.

Hi-Speed Heating—2 Min/Inch

Extremely rapid heating minimizes scale.

Typical Operation:	Material:	4″ cubes — aircraft steel
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	Heating Time:	8 minutes
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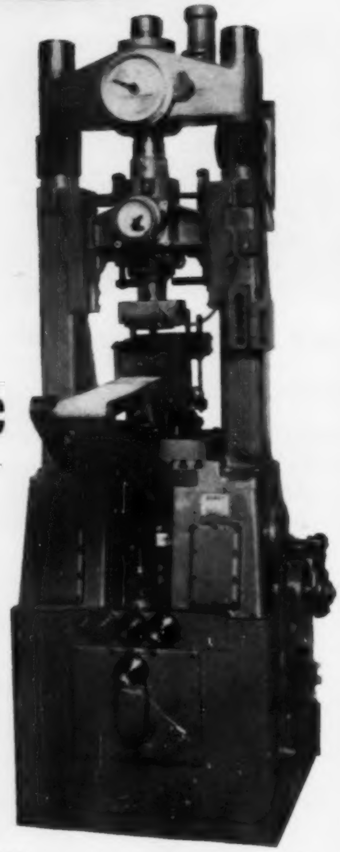

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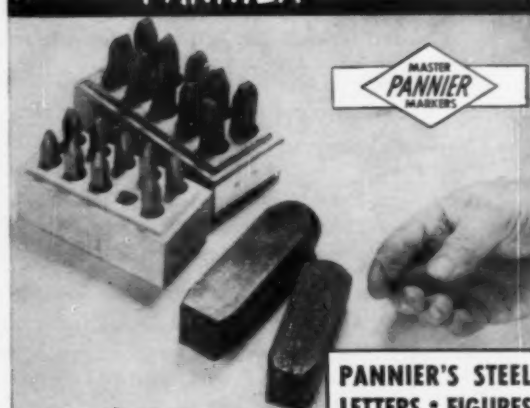

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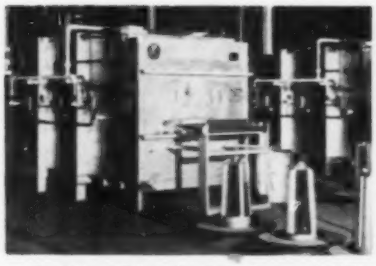
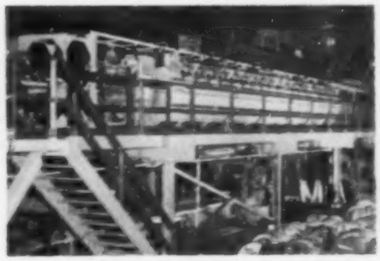
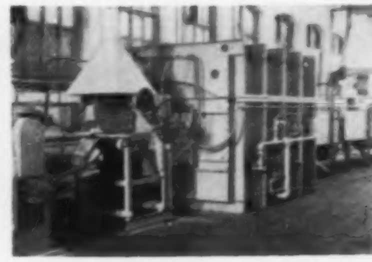


An EF multiple tube type furnace bright annealing stainless steel wire, continuously. One of an installation of five stainless steel furnaces we built in a prominent steel plant.



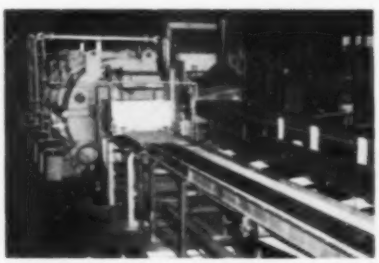
Large capacity EF gas fired furnace bright annealing stainless strip. We build them electrically heated or gas fired for wide or narrow strip, for single or multiple strands.



Stainless steel strip in various widths is bright annealed continuously in this EF gas fired special atmosphere installation equipped with an EF gas fired ammonia dissociator.

Bright Annealing Stainless

Tubing, Strip, Wire, Stampings and Other Stainless Steel Products



Stainless Steel Tubing in various diameters and lengths up to 24 feet is bright annealed continuously in this EF gas fired furnace.

Stainless steel strip, wire, heavy and fine tubing, stampings, flatware, cooking ware, drawn and other stainless steel products, in many shapes and forms, are being bright annealed, uniformly, economically, continuously and with laboratory precision in EF furnaces of various sizes and types we have built.

Extensive experience with stainless steel problems, backed by over 40 years of practical furnace building experience and thousands of successful fuel fired and electric installations, enable EF engineers to design and build the best size and type of equipment needed for handling any product or production, or for any heat processing requirement.

Stainless Steel Strip. Wide, narrow and in various types, is uniformly bright annealed, continuously, in EF furnaces — any tonnage.

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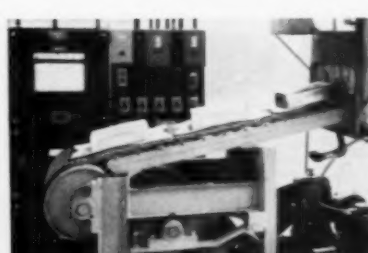
EF THE ELECTRIC FURNACE CO.

GAS FIRED OIL FIRED AND ELECTRIC FURNACES FOR ANY PROCESS, PRODUCT OR PRODUCTION

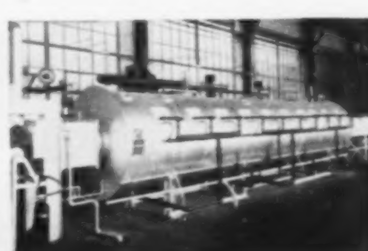
Salem - Ohio

Canadian Associates • Canefco Limited • Toronto 1, Canada

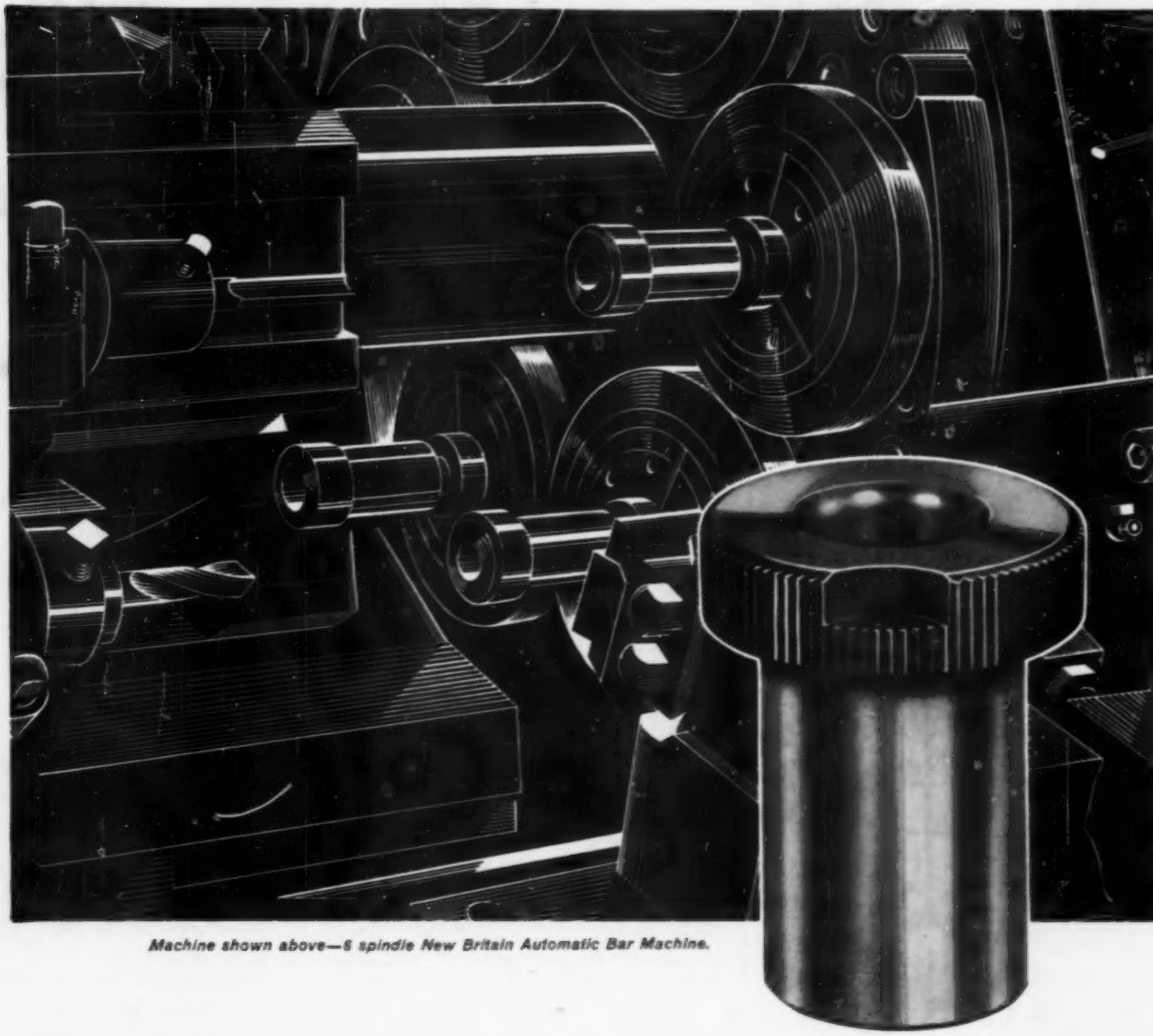
Stainless Steel Wire is bright annealed in this and other EF continuous and batch type gas fired and electric furnaces we build.



Stainless Steel Stampings, flatware, drawn and other products; large, small and in various shapes are bright annealed in EF furnaces.



Another type we build for bright annealing stainless strip. This EF furnace also handles other grades requiring lower temperatures.



Machine shown above—6 spindle New Britain Automatic Bar Machine.